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ORIGINAL ARTICLES.

I.—On the Amygdaloids of the Tynemouth Dyke.[1]

By J. J. H. Teall, M.A., F.G.S.

(PLATE XIV.)

In a paper published in the Quarterly Journal of the Geological Society for 1884,[2] I gave some account of the Tynemouth Dyke. In that paper, however, I omitted to describe one feature, connected with the microscopic structure of the dyke, because at the time of writing I did not understand it. A short time ago I had occasion to re-examine my preparations, when my attention was again directed to the feature in question; and this time an explanation suggested itself which appears to be in every respect satisfactory. The main object of this communication is to supplement my already published description by giving an account of the feature to which I have referred, and which may be briefly described as the occurrence of spherical patches of interstitial matter. (See Pl. XIV. Fig. 1.)

At the time of my residence at Tynemouth (1882) the dyke was exposed in the angle formed by the breakwater and the cliff on which the Priory stands, and also in the cutting close to the railway station. The rock of which the dyke is composed varies somewhat in character owing to the presence or absence of porphyritic felspars and small spherical amygdaloids. A typical specimen may be said to consist essentially of porphyritic crystals, or rather crystalline aggregates of a felspar closely allied to anorthite, embedded in a dark, finely-crystalline ground-mass, composed of augite, lath-shaped felspars, and interstitial matter. Olivine has been detected in one or two slides; but it is not usually present.

The porphyritic constituents undoubtedly belong to the earliest phase in the consolidation of the original mass of molten matter. They consist, as a rule, not of single crystals, but of two or more individuals. Where the individuals of one and the same group are in contact with each other, they exhibit no trace of crystalline form;[3] but where they are in contact with the ground-mass, they are bounded by definite faces. In other words, the internal relations of the individuals forming a group are those of plutonic rocks (*e.g.* gabbro), whereas the external relations of the same individuals are those of volcanic rocks. This, of course, is in strict accord with the general view that the porphyritic constituents have been developed under plutonic conditions. An examination of the porphyritic aggregates

[1] Read at the Brit. Assoc., Newcastle-on-Tyne, in Section C. (Geology), Sept. 1889.
[2] Petrological Notes on some North of England Dykes, vol. xl. p. 233.
[3] See fig. 1, plate xiii. accompanying the paper already referred to.

under crossed Nicols reveals the fact that the felspar-substance to which the external idiomorphism is due differs from that forming the central portions. This, taken in connection with the fact that the augite-grains of the ground-mass are occasionally included in the peripheral zone of the porphyritic groups, justifies the conclusion that such external form as the individuals possess was given to them at a later stage in the history of the consolidation of the rock than that at which the groups themselves were formed, and also under different physical conditions.

The augite is pale in colour, and occurs in grains or granular aggregates. It is occasionally penetrated by the lath-shaped felspars, and must, on the whole, have been formed after them.

The lath-shaped felspars call for no special description. They frequently show multiple twinning of the usual type.

The interstitial matter contains extremely minute microlites and skeleton crystals of felspar, grains and skeletons of magnetite, and an indistinct brownish granular substance. It is not possible to recognize any true glass, even with the highest powers. This interstitial matter occurs in more or less angular patches wedged in between the other constituents, and gives to the rock the structure for which Professor Rosenbusch has proposed the term *intersertal*. The rock itself would be termed by this author a tholeite.

Now the peculiar feature to which I wish to call special attention is the occasional occurrence of spherical patches of interstitial matter. These appear in the thin sections—and they have only been recognized in the sections—as circles. How are these spherical patches to be accounted for? An answer to this question is found by studying the amygdaloids, which have been already referred to as occurring in certain portions of the dyke. (See Pl. XIV. Fig. 2.)

Microscopic examination enables us to determine the precise stage in the history of consolidation at which the vesicular cavities, now for the most part filled with carbonates with or without a narrow border of chalcedony, were formed. Their development evidently displaced the lath-shaped felspars, for these are often arranged tangentially with reference to the bubbles; but it produced no effect on the disposition of the constituents of the interstitial matter. It appears, then, that the gas bubbles were produced after the formation of the porphyritic constituents, the augite and the lath-shaped felspars, but before the consolidation of the interstitial matter. It is possible that their development was due to the relief of pressure consequent on the rise of the semi-liquid mass in the crack. If so, then they are analogous, so far as their mode of formation is concerned, to the bubbles which arise in the contents of a soda-water bottle as the cork is partially removed.

Now, the spherical patches of interstitial matter agree in form and size with the amygdaloids, and to account for them we have only to suppose that the portion of the mass which was liquid at the time of their formation, oozed into some of the vesicles owing to the absorption, escape, or condensation of the gas. That this is the true explanation is proved by the occurrence of cavities which have been only

partially filled up. (See Pl. XIV. Fig. 3.) The last act to which we have to call attention was the filling up of the cavities remaining empty after final consolidation with chalcedony and carbonates.

We may summarize the history of the rock so far as it is recorded in microscopic structure as follows:—

1. Development of granular aggregates of a felspar allied to anorthite under plutonic conditions.
2. Addition of felspar substance to the external portions of the granular aggregates, and the consequent production of crystalline form.
3. Development of lath-shaped felspars. 4. Separation of augite.
5. Formation of vesicles owing to the separation of gas from the magma.
6. Partial or complete filling up of some of these vesicles with interstitial matter.
7. Consolidation of the interstitial matter. [carbonates.
8. Filling up of the vesicles remaining empty after final consolidation with

EXPLANATION OF PLATE XIV.

Augite is indicated by dots, interstitial matter by lines. The felspar is left clear. Magnetite is black.

Fig. 1. Vesicle filled with interstitial matter.
„ 2. „ filled with carbonates.
„ 3. „ partly filled with interstitial matter and partly with carbonates.

II.—The Effects of Pressure on Crystalline Limestones.[1]

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

THOSE who have carefully studied the crystalline schists cannot fail to have noticed that a community of structure—a sort of family likeness—prevails throughout any one group of rocks, while those which occur apparently at different horizons exhibit dissimilar structures. Thus the marbles associated with any group of crystalline schists are coarse or fine in grain, according to the structure of the latter. But to this rule exceptions appear, at first sight, not infrequent. For instance, in the Alps, we find not uncommonly, in that group of schists which seems to occupy the highest position, marbles which present an abnormally compact aspect. On closer examination they prove indeed to be crystalline in structure, but the crystals seem so small, the general structure so compact, that until we find them graduating into typical mica or other schists, we can hardly feel satisfied we are not being duped by infolded limestones of Mesozoic or Palæozoic age. When, however, we study the microscopic structure of such crystalline limestones, the abnormality proves to be more apparent than real. This compact structure is due, not to the absence of crystallization, but to the destruction by pressure of an original crystalline structure: for we find on examination that the rock, once perhaps coarsely crystalline, has been crushed and again consolidated, so that it has now assumed a comparatively compact appearance.

A proof of the above statement may be afforded by a brief description of the structures which are exhibited by a series of limestones[2] which I have from time to time collected and examined.

[1] Read before Section C, Brit. Assoc. Newcastle-upon-Tyne Meeting, Sept. 1889.

[2] Many of the Alpine limestones, both in the Mesozoic and in the Crystalline series, are more or less dolomitic, but I have not thought it necessary to distinguish these. The statements apply to both, except that, among the ordinary sedimentaries, the

In the Alps, as is well known, large masses of limestone occur which are indubitably of Mesozoic age. Sometimes these have been exposed to great pressure; sometimes they appear to have been uplifted with comparatively little disturbance. In either case there does not appear to be a very marked difference in their crystalline condition. A Mesozoic Alpine limestone may be described in general terms by saying that it resembles, often closely, in texture and sometimes even in colour, one of the Carboniferous limestones of Britain—that is to say, it varies from black to grey—though the peculiar light grey of the English Carbonifeous limestone is, so far as I know, most unusual. Not seldom the rock is yellowish in colour, like some of our Mesozoic limestones, but with a different texture; occasionally it is reddish. Even where the calcareous constituent exhibits a crystalline character, it is obvious that, if this were removed by the action of an acid, the residue would be, roughly speaking, mud, silt, or sand which, as a rule, has not undergone more alteration than would be observed in the above-named British rocks. If, however, we examine a limestone which both is indubitably associated with a series of crystalline schists and has been selected from a comparatively undisturbed region, we find that whether coarse or fine (in the latter case of course the statement may be less precise) the constituents throughout are in a crystalline condition. If quartz-grains are present, they bear no resemblance to those in a sandstone, but have evidently assumed their present outline *in sitû*.[1] If mica, it is in like way evidently authigenous. So also with the malacolite, sahlite, or other mineral constituents. In short, it is evident that, whether the rock were originally an organic aggregate, a chemical precipitate, or a detrital accumulation, the constituents have undergone a molecular rearrangement, which is in all cases considerable and is often complete.

If now we turn from the examination of such specimens to one of the abnormal-looking limestones, collected from a crystalline group which has been exposed to severe pressure, we find that its constituents, as before, are in a crystalline condition, but that the structure of the rock is different. Instead of finding a considerable uniformity in the size of the calcite grains, we observe a marked diversity. In a ground-mass of granules are scattered grains variable in size and number, subangular or slightly irregular in outline, and sometimes exhibiting a slightly linear arrangement. If an outline sketch were made of the slide, it might be supposed to represent a subangular breccia or conglomerate—except that the outline of the larger grains is slightly irregular or 'ragged.'

Further, many of these grains exhibit the twin lamellæ, which, as is well known, can be artificially produced in a calcite crystal by pressure, and which, if they occur in rocks, are now commonly

'dolomites' generally have a more crystalline aspect, and, among the crystalline schists, do not usually show mineral cleavage so readily as those which only contain calcite; they also exhibit the usual differences to which I called attention in 1879 (Q.J.G.S. vol. xxxv. p. 167).

[1] Of course they may have had a clastic nucleus, but of this their present outline shows no trace.

regarded as indicative of the same disturbing cause.[1] Not seldom there seems to be a tendency to orientation in these lamellæ, since they either lie in or make angles of about 20° with the rude planes of incipient cleavage in the rock; these, of course, being roughly perpendicular to the direction of pressure.

The well-known crystalline limestone of Tiree is an interesting example of the same process. This rock was for some time a puzzle to me, for the large size of the sahlite grains, which were such as might be expected from the geological position of the rock, seemed to be incongruous with the apparently compact calcareous matrix. One would have expected the latter to resemble the crystalline calcite in one of the malacolite limestones in the "Granville series" of Canada. But an examination of a set of slides prepared from specimens of the Tiree rock has removed the difficulty. The brecciated or conglomeratic structure above described is at once revealed by the microscope. Grains of calcite, of various sizes, in some cases almost as large as those of the sahlite, are scattered about in a finely granular matrix of calcite, which gives the usual indications of having suffered from pressure, although subsequently it has been completely reconsolidated. On closer examination, we find here and there a grain of calcite, either occupying an inlet in one of the sahlite grains or sheltered between two adjacent grains of the same, which has evidently formed part of a larger grain, and which indicates that the calcite matrix was once in a coarsely crystalline condition and that its grains corresponded in magnitude with that of the sahlite. In one case that I have examined the accidental proximity of some sahlite grains has so protected the calcite that two or three crystals of it remain unbroken, and we can, as it were, study a fragment of the original rock. In one instance, adjacent to an unbroken grain of calcite, are some of much smaller size, which, in their relation to the matrix and their disposition, suggest that an original grain, thus imperfectly protected, has been broken up but not crushed. The matrix of the slide consists of calcite granules, in which a faint streaking is seen, suggesting the action of pressure. It is remarkable that the sahlite grains do not appear in my specimens to be broken or even distorted. Probably they have been saved by the easy cleavage and brittleness of the calcite, which was reduced to a powder by the pressure, and again consolidated as the latter diminished.

Miss C. A. Raisin has recently shown me a specimen, collected by herself, in which the effect of pressure on calcite is well illustrated. It is a brecciated volcanic rock (?andesite) from Porth Oer, north of Aberdaron, the fissures in which have been filled up by calcite with a little quartz. In consequence of subsequent pressure the quartz is displaced and shows strain-shadows, but the calcite exhibits various stages of crushing, as described above, most of it being reduced to granules, and these sometimes are slightly 'streaky' in their arrangement. Here then the history of the rock is complete and there can be no doubt as to the cause of the structure.

Hence the observations—and they have been rather extensive—

[1] Rutley, Rock-forming Minerals, s.v. *Calcite*.

which have been briefly summarized above, lead me to the following conclusions :

1. While I would not venture to affirm that pressure has no effect in producing crystallization in a limestone, this is only small and subordinate, quite insufficient as a rule to obliterate the ordinary character of a limestone, such as occurs in strata of later Palæozoic or of Mesozoic age. Certainly, as is shown by the study of limestones into which igneous masses have been intruded, the effects of pressure are far less marked than those of heat, under circumstances which appear to be otherwise similar.

2. When limestone already crystalline has undergone severe pressure, its structure, macroscopically and to a considerable extent microscopically, is rendered less coarsely crystalline, *i.e.* instead of becoming more distinctly crystalline, it is made to resemble more nearly an ordinary limestone (non-oolitic and unfossiliferous) such as might be obtained in Derbyshire, in South Devon, or in many parts of the Alps.

Perhaps I should add that I am fully aware that some geologists, whose opinion is entitled to respect, have recently asserted that certain crystalline limestones in the last-named district are Jurassic rocks which have been altered by pressure. The typical instance of this, as it may be called, has long been known to me, and has been recently examined anew. It will take some time to complete the study of the specimens which have been added to my collection, and until that is done, I will say no more than that this identification appears to me an hypothesis, in support of which only a little and against which very much evidence can be adduced.

Indeed, as I hope to show in a paper now nearly completed, which will include the results of this and other work in a like field, the direct effects of pressure are rather destructive than constructive—a matter which I think has sometimes been overlooked in speculations on 'pressure-metamorphism.' It is but a part of a chain of sequences, though here also it may be true that (to speak figuratively) "mille animas una necata dedit."

III.—Terrestrial Magnetism as Modified by the Structure of the Earth's Crust, and Proposals Concerning a Magnetic Survey of the Globe.[1]

By Dr. Edmund Naumann.

"THE study of any new science," says Alexander v. Humboldt, "may be compared to a journey to distant lands. Before starting in company with others, the question as to the practicability of the journey is raised; while examining one's own powers, the qualities of fellow-travellers are looked upon with distrust. It is feared—perhaps without just reason—that they might cause unpleasant detention. In our time the difficulties of an undertaking of this kind are much diminished. Any confidence is founded on the bright blossoming state to which natural sciences have grown, their wealth being no more the abundant quantity, but the concatenation of what has been observed."

[1] Read at the Brit. Assoc. Newcastle, before Section C (Geology), Sept. 1889.

These remarkable words were spoken nearly half a century ago. Since then natural sciences have undergone enormous development, many methods of investigation have been completely changed, and the aim of concatenating facts has greatly influenced the methods of observation. Systems which were then descriptive have been replaced by others in which the various facts are arranged, so as to exhibit their relation to causes, and by reducing the number of isolated facts, different fields of investigation have been brought into closer relationship.

The change which has taken place is particularly striking in the case of Mineralogy. Modern mineralogists devote considerable attention to Physical Crystallography, a study which borrows its methods from a sister science, and the results attained by the combination are very satisfactory.

By the aid of light we are enabled to discern the structure of crystallized bodies, and to trace the marvellous connection between composition, structure, and form. The motions of light, although the best, are not the only means of investigating internal structure, for those of heat, electricity, and magnetism, also depend on the shape, size, and arrangement of the smallest particles and their interstices. Any interposition, any fissure, causes changes of wave motion, for this motion can only be propagated regularly in homogeneous media, and its character, velocity, and direction of propagation are altered wherever any variation from homogeneity exists.

Changes of this kind occur even at the planes of composition of twin crystals, where no alteration of substance, but a mere change of structure, takes place. In the same way, the electric currents passing through the earth's crust must be diverted, or accelerated, retarded, or modified, wherever the uniformity of composition is interrupted. Such interruptions will be caused by deep fissures, once open at the surface and leading towards the earth's interior. These clefts cannot generally be found by direct observation, but require the aid of geological research.

At the present day, probably the majority of physicists consider the globe to be a body of very uniform composition or structure, and though it is generally admitted that there is a change of structure radially, the irregularities which divide one and the same of the presumed concentric layers into unequal parts, are generally neglected, although geology has proved the predominance of such irregularities in the earth's crust.

Modern geology no longer accounts for the differences between observed and calculated polar altitudes by assuming constant errors, the compensation of which is effected on the method of Least Squares. We know that the earth is irregular in form, and that its shape cannot be expressed by any mathematical equation. The so-called geoid is not geometric in form, and there is in fact an infinite number of geoids. These discoveries have greatly limited the application of the method of Least Squares. Irregularities exist not only in the form of the earth, but also in the distribution of matter, and precautions are just as necessary in physiographical researches as in geodetic investigations, if a mathematical compensa-

tion of errors is to be attempted. Though errors of observation cannot be avoided, there is no doubt that in many cases deviations from a certain expected result are not due to errors, but to actual irregularities presented by nature. These deviations were formerly referred to accidental causes or to local influences, and the unexpected results were considered anomalous and disappointing; and even up to the present day it has been customary to arbitrarily modify results which do not agree with mathematical formulas, and to constrain curves that would not otherwise have exhibited the expected regularity.

The earth's crust is considerably broken and fissured, and its superficial layers folded; these disturbances must have some influence on the phenomena resulting from the motions which we call heat, electricity, and magnetism. Of these forces, magnetism is the one most useful in the study of the earth's structure, and just as optical phenomena are employed in researches on the internal structure of crystals, those of magnetism may be used to investigate the internal structure of the globe. Magnetic phenomena may be regarded as telegraphic messages from distant depths, but, unfortunately, in the present state of science, it is impossible to decipher them.

In a memoir entitled "The Phenomena of Terrestrial Magnetism in their Dependence upon the Structure of the Earth's Crust,"[1] I have given a large number of instances in which the distortion of magnetic curves are caused by clefts in the crust, and have pointed out that the isogonic lines afford the clearest indications of a connection between magnetic and structural conditions. The 'isogones' are much more important than the magnetic meridians; this will be easily understood as soon as electricity and magnetism are considered to be different manifestations of one and the same force. From recent investigations made in Germany it is highly probable that an intimate connection exists between Earth Currents and Terrestrial Magnetism, and if this be true, deviations in the direction of the currents ought to be accompanied by changes of declination. For such reasons I consider the Isogones to be the best indicators of the course of the earth-current.

The systems of magnetic curves show very distinctly a relation to mountain ranges, faults, eruptions, and tectonic disturbances, wherever a detailed magnetic survey has been made. Irregularities in the curves are so frequent that their existence could not be denied even at the very beginning of magnetic surveying; however, they were not attributed to want of internal uniformity of the globe, but to the influence of magnetic masses at or near the surface, to denote which, the special name "Rock Magnetism" was introduced. There *are* magnetic rocks *at the surface*, and almost any kind of rock, such as Serpentines, Granites, Syenites, Porphyries, Diorites, Trachytes, Andesites, Basalts, etc., may act on the needle, but there are no magnetic rocks *below the surface!* Even magnetic iron ore does not show a trace of magnetism directly after it is taken from the mine,

[1] Die Erscheinungen des Erdmagnetismus in ihrer Abhängigkeit von Bau der Erdinde. Stuttgart, 1887

but the magnetic property is developed after being exposed to the atmosphere for some time.

In the above-mentioned memoir I have endeavoured to prove that the so-called "rock magnetism" does not produce the distortion of magnetic curves, and I here quote one example to show how insignificant these local disturbances are. The long chain of mountains, Katschanar-Blagodat-Wissakaja Gora of the Ural, consist chiefly of magnetic iron ore, and although the compass is strongly affected in the immediate neighbourhood of the ore in the quarries, yet the chain produces no remarkable distortion in the system of magnetic curves. Other examples might be given to show that "rock magnetism" is a secondary phenomenon confined to the *very surface* of masses, and not a property of the masses themselves. Moreover, the surfaces of rocks which exhibit magnetic properties, generally present a considerable number of irregularly distributed poles.

The connexion between magnetic and structural phenomena was foreseen by several distinguished observers. It was on the 26th of May, 1849, that Kreil read his paper "On the Influence of the Alps on the Reactions of the Magnetic Force of the Earth."[1] He was not clear about the tectonic relations, but knew with certainty that some connexion existed between magnetic phenomena and the internal condition of the earth's crust, and that the cause of mountain ranges had considerable influence on the direction of the magnetic curves.

At a still earlier date Locke communicated his paper to the American Philos. Soc. of Philadelphia.[2] In it, many interesting observations were made which might have been followed with advantage, but unfortunately his work, like that of many others, was forgotten. He surveyed magnetic profiles, and plotted inclination curves having distances as abscissæ and "magnetic dips" as ordinates. The curve for the line passing over the horizontally stratified rocks of the West, through Kentucky and Ohio, and along the Mississippi, shows generally a very gradual rise until it crosses eruptive rocks between Baltimore and New York, where it exhibits a rise and fall "like the contour of primitive or igneous mountains." (See Plate XV. Fig. 1.)[3]

Many extensive surveys have been made since Humboldt and Gauss brought the subject into prominence, but there have been few observers who were not somewhat embarrassed by the mathematical theory of Gauss, and nearly all have considered the irregularities in magnetic charts as something accidental, anomalous and vexatious. The recent activity in magnetic surveying is very gratifying, but many observers still use the old methods, although they are capable of considerable improvement.

The rate of progress could be further accelerated by establishing

[1] Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathem. naturwissench. Klasse. Bd. I. Wien, 1850.

[2] Locke, Observations of the Magnetical Force in several parts of the United States. Trans. Am. Phil. Soc., Philadelphia, vol. ix. 1846, p. 283.

[3] The Plates illustrating Dr. E. Naumann's paper will accompany Part II. in December Number GEOL. MAG.—EDIT.

and following a general scheme for a Magnetic Survey of the whole globe, and united efforts might considerably reduce the labour involved in so great an undertaking. It is very desirable that such a systematic and complete survey should be taken in hand, instead of giving particular attention to limited districts, and I solicit the help of those interested in the subject, in starting an undertaking in which we may be sure that all nations will gladly join.

(*To be concluded in our next Number.*)

IV.—On the Systematic Position of the "Dendrodont" Fishes.

By Dr. R. H. Traquair, F.R.S., F.G.S.

In a short paper on the nomenclature of the Old Red Sandstone Fishes published in this Magazine for November, 1888, I expressed the opinion "that the scattered teeth and fragments of jaws known as *Dendrodus* and *Lamnodus* belong to fishes at present known to us by their scales as species of *Holoptychius* and *Glyptolepis*." The family terms "Holoptychiidæ" and "Dendrodontidæ" I consider absolutely synonymous. On the other hand, the Rhizodontidæ (*Gyroptychius*, *Tristichopterus*, *Rhizodus*, etc.) present a somewhat different form of tooth-structure, and one which is, in the main, identical with that which, in so many Stegocephalous Amphibia, is called "labyrinthodont."

The reasons in support of this opinion are something considerably beyond the region of conjecture,—they amount to positive proof.

As far back as 1849, Hugh Miller[1] figured portions of jaws with teeth, as well as microscopic sections of teeth from Thurso, which are undoubtedly referable to Owen's genus *Dendrodus*, both as regards external configuration and internal structure. Of this Miller was aware, though he refers them to *Asterolepis*, Eichwald, along with the large cranial shields and other remains of a great coccostean fish, *Homosteus* of Asmuss. Now nothing can be more certain than that these dendrodont teeth from Thurso belong to a large species of *Glyptolepis*, in more than one head of which, belonging to the Edinburgh Museum, they may be seen in *situ*. This *Glyptolepis* is also identical with Agassiz's "*Platygnathus*" *paucidens*.

As regards the *very* closely allied Upper Old Red genus *Holoptychius*, I have not obtained any microscopic sections of teeth found in *situ*; but, to judge from the external characters of these teeth, as seen through a good hand-lens, it is impossible to doubt their dendrodont nature. And finally the portions of jaws which occur displaying teeth of "Dendrodus" are undoubtedly Holoptychian in their configuration.

Now, the occurrence in the Holoptychiidæ of pectoral fins displaying the "archipterygeal" configuration clearly enough shows that there must be *some* genetic connection between this family and the Dipnoi. I was therefore interested to read in the introduction to a recent paper on this subject[2] by Dr. J. V. Rohon that the

[1] Footprints of the Creator, first edition, 1849, figs. 30, 31, 32 and 33.

[2] Die Dendrodonts des devonischen Systems in Russland, Mem. Acad. Imp. Sc. St. Petersbourg (vii.) vol. xxxvi. No. 14, 1889.

"Dendrodonts" do not belong to the Ganoidei, but to the Dipnoi, as he had been able to prove the autostylic condition of the skull—"d.h. das mit dem Schädel unbeweglich verschmolzene Palatoquadratum und das verkümmerte Hyomandibulare." On reading the paper, however, and examining the two very pretty plates by which it is illustrated, one is rather disappointed as to the evidence which Dr. Rohon has adduced to prove his position.

It is of course not always easy to identify every part of a fossil fish skull from drawings only, but there are a few points concerning the fossil figured by Dr. Rohon as the "skull" of *Dendrodus biporcatus* which are self-evident.

This "skull" (pl. i. fig. 1) is not the entire skull, with several body-vertebræ fused with it, as Dr. Rohon seems to imagine, but only the anterior part or snout broken off near the interorbital region. His "pterygo-palatine" bones are the two elements of the duplex vomer, each of which, as in the Rhizodonts and Saurodipterines, bears one or more large tusks. The skull being broken off quite anterior to the brain-cavity, it will hardly be appropriate to designate anything here displayed as "quadrate" or "hyomandibular," the parts so lettered being in reality ante-orbital in position! What Dr. Rohon interprets as orbit (though indeed with a query) is a crevice apparently at the postero-external part of the premaxilla.

Dr. Rohon seems to put great weight on the "einheitlichen Hautknochen" by which the "Schädeldecke" is represented. The fusion of the dermal plates of the snout with the premaxillæ into one piece is not, however, a very rare phenomenon in Devonian Crossopterygii, and is indeed well seen in a large skull of *Glyptolepis paucidens* in the Edinburgh Museum.

In fig. 3 Dr. Rohon represents a broken-off snout which he refers to a new species of *Cricodus* (*C. Wenjuckowi*). Here the supposed "orbits" have a most suspicious resemblance to nasal openings. The orbits in many old fossil fishes are anterior enough, it is true, but not quite situated upon the very front of the snout itself.

In fig. 10 Dr. Rohon has given a view of a dentigerous fragment from Thurso which he supposes to be a part of a skull of *Dendrodus* showing the cranial cavity. As the diameter of the supposed cranial cavity is not greater than that of the base of the large tooth attached to the specimen, this interpretation can hardly be correct.

Nor can I admit that the dentigerous fragment depicted in his fig. 11 represents the entire mandible either of *Dendrodus* or any other fish. I think also that Dr. Rohon is hardly entitled to explain the discrepancies between this fragment and the mandibles, figured by Pander, Trautschold and Agassiz, on the supposition that they belonged to fishes which, though "allied to the Dendrodonts in the structure of their teeth, were tolerably far removed from them as regards the constitution of the lower jaw, and probably also of the skull."

At the end of the paper he gives an "attempt at a restoration" of *Dendrodus biporcatus*, Owen. Here the body and fins are formed as in *Gyroptychius*, and, if the author considers *Dendrodus* to be a

Dipnoan, it is certainly strange that he should represent it with the obtusely lobate pectorals of the Rhizodonts and Osteolepids instead of with the acutely lobate or unabbreviate archipterygeal members of *Ceratodus* or *Dipterus*. Except the mandible, no bones are marked off on the head, in accordance with the idea that the cranial roof is represented by a single dermal bone, while near the end of the snout are placed two minute orbits. It is to be hoped that no future compilers of geological or palæontological text-books will copy this extraordinary figure and insert it as a "restoration of *Dendrodus*."

As the result of his researches Dr. Rohon announces that the genera *Dendrodus*, Owen, and *Cricodus*, Agassiz, are not Ganoids, and considers that they should be reckoned as forming a peculiar order of Dipnoi. Of this supposed "order" he gives the following definition:—"Fishes with depressed head, whose surface-ornament consists of ridges and tubercles. The free margin of the snout is set with numerous small teeth, whose folded dentine encloses a spacious pulp-cavity. Two powerfully developed palatal teeth, which are intimately united with the pterygo-palatine, and within the folded dentine contain a spacious pulp-cavity; they are placed asymmetrically. The bony quadrate is fused with the skull. A styliform parasphenoid displays on its surface a tract of little tubercle-like teeth, and is the bearer of several fused vertebræ, drawn into the skull. Very small orbits (?) and two internal nasal openings are present. The skull-roof represents a simple dermal bone, whose histological structure corresponds to that of true osseous tissue."

Now as this definition is founded upon an entire misinterpretation of the specimens figured in the paper, I fear it can only be looked upon as a curiosity of scientific literature. Whatever relationship "*Dendrodus*" may have with the Dipnoi, it is certainly not in the manner indicated by Dr. Rohon, and I for one do not as yet see any reason for separating the Holoptychiidæ, of which I consider "Dendrodontidæ" to be a simple synonym, from the Crossopterygian Ganoids.

Again, I must refer to my paper on the nomenclature of the Old Red Sandstone fishes with regard to *Cricodus*, which Dr. Rohon also includes in his Dendrodont Dipnoi. If Pander's *Polyplocodus* be synonymous with Agassiz's *Cricodus*, then the latter is certainly not a Dendrodont or Holyptychian, but a Rhizodont.

V.—On Zonal Structure in Olivine.

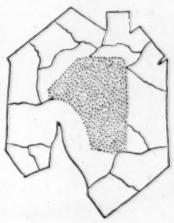
By J. Shearson Hyland, Ph.D., M.A.,
Of Her Majesty's Geological Survey.

In a recent paper on the volcanic rocks of Kilimandjaro I referred to the presence in the basaltic lavas of olivine crystals, which appeared to possess zonal structure. Although actual proof was wanting, still the symmetrical arrangement of the inclusions, as also the mode of alteration of the crystals, rendered the occurrence of such a structure highly probable. The olivines, being rich in iron, were altered into ferric oxide or ferric hydrate; and the line of

division between the fresh and decomposed portions was mostly parallel to the crystallographic outlines.[1] There was, however, no break in the optical continuity, such as the presence of zonal structure would demand.

A microscopical examination of some similar rocks from the same locality has led to the gratifying discovery of true evidence of zonal structure in this mineral. Fig. 1 shows a corroded olivine exhibiting this phenomenon. The inner zone is shaded in order to graphically represent its outline with reference to the contours of the crystal.[2] The zones are dissimilar in their optical behaviour, the difference between their extinction-angles being as much as 6°. In transmitted light there is a trace of the structure apparent; the upper line of division being a plane of fracture, the lower being marked by glass inclusions.

Fig. 1.



The literature on the subject is not extensive. Van Werveke, in 1879, seems to have been the first to suggest the possible occurrence of zonal structure in this mineral. In his paper on the Palma basalts he mentioned the presence in this constituent of glass inclusions, which were arranged parallel to the crystallographic outlines. This induced him to expect zonal structure.[3] In the same year Hofmann formed a similar opinion as the result of his observations of the presence of "zones which were different in their optical characters and in their manner of alteration."[4] Bruno Doss, in his paper on Syrian basalts, described and figured olivines composed of concentric layers, but was able only in one instance to note a variation in the polarisation tints.[5] Stock has also mentioned a similar experience.[6] I fail, however, to find any instance recorded where the difference in the extinction-angles was so great as to allow of its accurate determination.

Crystals grow by accretion, that is, by the addition of matter to their external surfaces. If this addition be regular and constant, the crystal formed will be a correct type of the species. But, if the growth be intermittent, complications will arise. In this respect a crystal is like a living organism: it is affected by its environment. The crystal modifies its surroundings, and is in turn modified by them: there is action and reaction between it and its environment. Intermittent growth must, accordingly, tend to produce zoned structure. In the case of isomorphous mixtures like augite and felspar this

[1] "Ueber die Gesteine des Kilimandscharo und dessen Umgebung." Tschermak's Mittheilungen, 1888, vol. x. pp. 224 and 226; also plate vii. fig. 2.

[2] The mineral gives reactions characteristic for olivine.

[3] "Beitrag zur Kenntniss der Gest. d. Insel Palma." Neues Jahrbuch für Mineralogie, etc., 1879, p. 820.

[4] "Die Basaltgest. des südlichen Bakony," Budapest, 1879, pp. 27 and 193.

[5] "Die basaltischen Laven und Tuffe der Provinz Hauran, etc.," Tschermak's Mitt. 1886, vii. p. 488; plate ix. fig. 32.

[6] "Die Basaltgest. des Löbauer Berges," Tschermak's Mitt. 1888, ix. p. 437; and plate ix. fig. 2.

tendency is particularly strong, and usually leads to the construction of crystals built up of innumerable layers, different in chemical constitution and often so fine as to require the microscope for their detection. Since olivine represents an isomorphous mixture of Mg^2SiO^4 and Fe^2SiO^4, it should be equally liable to this structure, and the poverty of observations on the point seems all the more remarkable.

If the outline of the inner zone be studied, decided evidence of its corrosion through the fluid magma, previous to the deposition of the outer shell, will be observed. This alone is proof of the two zones representing different periods of growth. The corroded form of this inner zone reminds us of the analogy existing between a crystal and an organism in manner of growth. The influence of the environment has already been referred to; but the regeneration of lost or injured parts [1] is also common to both. M. L. Pasteur has particularly studied this property in crystals. He refers to the process as follows: "Quand un cristal a été brisé sur l'une quelconque de ses parties et qu'on le replace dans son eau mère, en même temps qu'il s'agrandit dans tous les sens par un depôt de particules cristallines, un travail très-actif a lieu sur la partie brisée ou deformée, et en quelques heures il a satisfait non-seulement à la régularité du travail général mais au rétablissement de la régularité dans la partie mutilée. . . . . La partie endommagée reprend peu à peu sa forme primitive, mais la travail de reformation des tissus est en cet endroit bien plus actif que dans les conditions normales ordinaires." [2]

Applying these observations to the case under consideration, we conclude that, corrosion having ceased and the constructive process having recommenced, growth was more rapid at the corroded than at the uninjured part of the crystal. Consequent upon this special activity, regularity of form was re-established, and, "regeneration" having thus occurred, constant accretion completed the crystal.

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VI.—On the Muscular Impressions of *Cœlonautilus*[3] *cariniferus*, J. de C. Sowerby, sp., compared with those of the Recent Nautilus.

By Arthur H. Foord, F.G.S., and G. C. Crick, F.G.S.

In examining the remarkably fine series of examples of *Cœlonautilus cariniferus*, mostly from the Carboniferous Limestone of Ireland, contained in the Geological Collections of the British

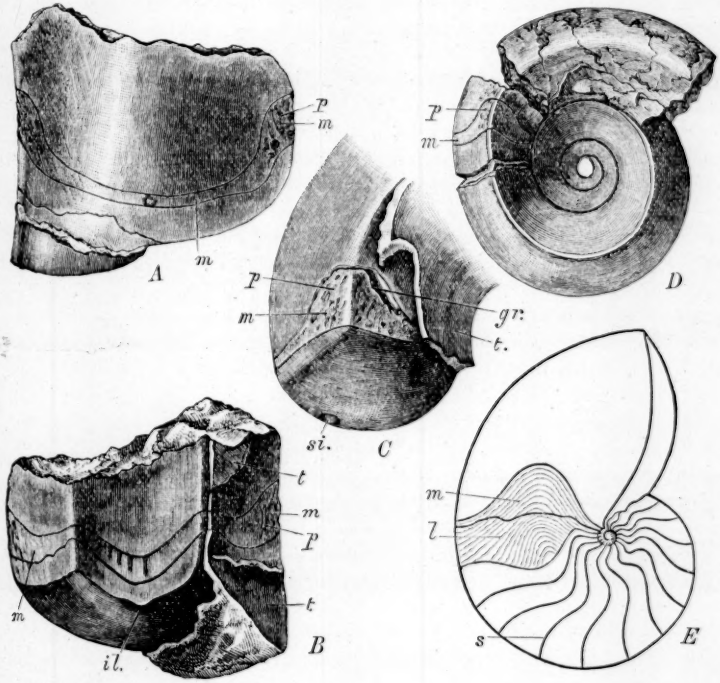
[1] Ger. Reproduktion verletzter Theile.

[2] "Etudes sur les modes d'accroisement des cristaux, etc." Compt. rend. tome 43, 1856, p. 795; see also, F. Scharff, "Ueber die ausheilung verstümmelter oder im Wachsen verhindert gewesener Krystalle, etc.," Pogg. Ann. vol. 109, 1860, p. 529; W. Ostwald, Lehrbuch d. allg. Chemie, Leipzig, 1885, Bd. i. p. 738; according to Scharff (l.c.) Jordan made an observation similar to Pasteur's as far back as 1842 (in Müller's Archiv.).

[3] This name from κοῖλον hollow (referring to the umbilicus), and *Nautilus*, is proposed by one of us in substitution for *Trematodiscus*, Meek and Worthen, which

Museum (Nat. Hist.), some were found to exhibit upon the cast of the body-chamber distinct marks of the shell-muscles. In one specimen (No. 50190) these are so perfect as to give a very clear outline of their form, and some of the test having been removed, their entire course can be made out.

The accompanying Figures (*A*, *B*, *D*) show the appearance of these muscular impressions, carefully drawn of the natural size, from this specimen.



Cœlonautilus cariniferus, J. de C. Sowerby, sp., from the Carboniferous Limestone, Cork, Ireland.—*A*, ventral or peripheral aspect of the base of the body-chamber (nat. size), showing at *m*, *m*, marks of the shell-muscles (*m* in all the other figures has the same meaning); *p*, in all the figures (exclusive of *e*) refers to the pitted and rugose surface of the muscular impressions: *B*, dorsal (internal) aspect of the same fragment, *t*, test, *il*, dorsal lobe of a septum: *C*, base of the body-chamber of a larger (? adult) specimen, *t*, test, *gr*, groove: *D*, reduced figure of a nearly perfect example of this species, from which the fragment lettered *A* and *B* was removed, as explained elsewhere in the text: *E*, outline, much reduced in size, drawn from a cast of the interior of *Nautilus pompilius*; *l*, finely impressed lines left by the shell-muscle, *s*, sutures of the septa.

was used by Häckel for a genus of Radiolarians. The name *Trematoceras* proposed by Hyatt (Proc. Boston Soc. Nat. Hist. 1883, vol. xxii. footnote, p. 291) in lieu of *Trematodiscus* is equally ineligible, because preoccupied, for although the species described by Eichwald (Leth. Rossica, 1860, vol. i. p. 1259)—*Trematoceras discors*—was a *Bactrites*, a generic name once published cannot be again employed, even for a different group, without risk of confusion.

A drawing has also been made (Fig. *E*), much reduced in size, from a cast of the interior of the shell of *Nautilus pompilius*, in order that the muscular impressions of *C. cariniferus* might be compared with those of existing species.

Fig. *D* represents the specimen selected for illustration, it is reduced in size from the original about one-half. The portion marked with the letters *p*, *m*, was removed from the rest of the shell in order that the muscular impressions might be drawn as seen in Figs. *A* and *B*, which are of the actual size.

Fig. *C* is taken from a larger (probably adult) specimen of *C. cariniferus* ("Sowerby Collection," No. 43861), and shows the marks of the shell-muscle on one of the angles of the whorl more distinctly than they can be seen on the smaller one.

We will now describe these figures more in detail. Figure *A* represents the ventral or peripheral side of the base of the body-chamber. The impressions of part of the shell-muscles are seen at *m*, *m*, while *p* indicates their rugose and pitted surface, and proves how strongly they were attached at the angles of the whorls; this is further evidenced by the deep groove *gr.* in Figure *C*.

Connecting the broader portions of the muscular impressions is a narrow band, near the centre of which there is a little shallow pit (see Figure *A*), which undoubtedly formed part of the muscular system, as the narrow band is slightly enlarged at this point to embrace it.[1]

Figure *B* is the under side of *A*. On this side it will be seen that the narrow band at its central part is strongly deflected backwards, in a similar manner to that of the annulus of the recent *Nautilus* (*N. pompilius*), so well figured (pl. xxxix. fig. 4) by Dr. W. Waagen in his well-known memoir entitled "Ueber die Ansatzstelle der Haftmuskeln beim Nautilus und den Ammoniden."[2]

The deflected portion bears several shallow, more or less elongated pits (see Figure *B*), which seem to indicate a rather strong attachment of the muscles at this point, though not so strong as at the angles of the whorls, where the muscular impressions are broadest.

Figure *C* represents the base of the body-chamber of a larger specimen than that from which *A* and *B* were drawn, and is designed to show more distinctly the pitted and rugose surface of the cast, proving, as already remarked, the strong attachment of the muscles at the angles of the whorl. Part of the test (*t*) has been removed in order to expose this part of the muscular impression more completely.

On examining the interior of the body-chamber of the shell of the recent *Nautilus* (either *N. pompilius* or *N. umbilicatus*) two somewhat inconspicuous lines (Fig. *E*, *m*) are observed, enclosing a space which on the dorsal and ventral sides of the shell forms a narrow band,—the impression of the annulus,—but expands at each side into an irregularly oval space,—the impression of the shell-muscle,—of which the outer boundary is strongly arched forwards. Corresponding in direction

[1] This enlargement is not indicated in the Figure, as it should have been.

[2] Palæontographica, bd. xvii. 1870, p. 185, plates xxxix. xl.

with the line forming the outer boundary, and covering the whole of the space between this and the last-formed septum, are a series of very fine impressed lines (marked *l* in Fig. *E*). These lines indicate successive points of attachment of the upper edge of the shell-muscle, representing a gradual forward movement, little by little, of the animal in its shell during growth. It should be observed that the line constituting the lower boundary of the muscular impression is only seen where the muscle was last attached.

That the organic attachment of the shell-muscles of the recent Nautilus to the shell was very slight (thus contrasting strongly with *Cœlonautilus*) has been pointed out by J. D. Macdonald[1] and subsequent writers.[2] Macdonald's description is so important and interesting in this connection that we quote it *in extenso* :—

"With reference to the action of the great lateral muscles of *Nautilus*, the following ideas have suggested themselves to my mind.

"As though preparatory to the complete separation of the body of the Cephalopod from the shell, which is usually present in the lower genera, the fasciculi composing the lateral muscles in *Nautilus* do not perforate the mantle, and therefore cannot be directly fixed into the shell; they are, however, connected with it through the medium of thin filmy layers of a corneous texture, which frequently remain attached to the shell after the animal has been removed. The feeble hold of those muscles, even in a very recent state, is thus readily accounted for. Indeed, it is highly probable that the fixity of the body of *Nautilus* during the inhalation and forcible ejection of the respiratory currents is effected by the shell-muscles reacting upon one another, on the principle of a spring purchase, rather than by simple traction, as illustrated by the withdrawal of a Gasteropod within its retreat, or the closure of a conchifer by the adductor muscles.

"This view, which is supported by the foregoing facts, has its principal basis in the line of direction of the shell-muscles, and the angle at which they meet one another, at the root of the funnel-lobe; for, the outer extremity of each being fixed, it follows that the first effect of the contraction of the muscular fibres would be to increase the angle just noticed; and this cannot possibly be accomplished, according to the recognized laws of muscular action, without tending to throw apart the points of origin, or, in other words, exerting outward pressure against the internal wall of the shell, and thus, as it were, jamming the occupant tightly in its cell."

In order that the above description may be more readily comprehended we here append a reduced copy of the figure given by Sir Richard Owen in his "Memoir on the Pearly Nautilus," 1832, plate 3, fig. 2.

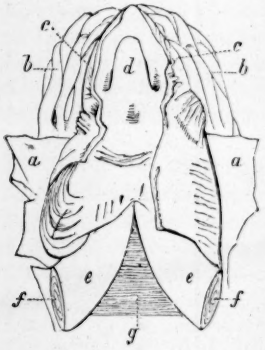
A comparison of the muscular impressions of *Cœlonautilus* with those of the recent *Nautilus* points to the conclusion that the animal

[1] Proc. Roy. Soc. 1856–7, vol. viii. p. 381.

[2] Prof. Blake, "Brit. Foss. Ceph." pt. i. p. 10; see also "Note on the Pearly Nautilus," by E. A. Smith, F.Z.S., in "Journ. of Conchology" for Oct. 1887; also 'Catalogue Fossil Cephalopoda,' British Museum (Nat. Hist.), pt. i. 1888, p. xi.

must in the former have been fixed more firmly in its shell than in the latter, and that in all probability the shell-muscles were not limited to the sides of the animal, as in the recent *Nautilus*, but completely encircled it.

The difference between the shell-muscles of *Cœlonautilus* and those of the recent *Nautilus* strongly supports the view that the two forms are *generically* distinct, a conclusion already arrived at from the great dissimilarity in the form of their shells by such an eminent authority as Prof. Hyatt. The subdivision of *Nautilus* was, in fact, begun long ago by M'Coy[1] and continued by Meek,[2] the latter of whom expressed his decided opinion that such divisions should at least rank as distinct subgenera.



Under surface of the head of *Nautilus pompilius*, with the mantle divided and the funnel turned back to expose its cavity and the shell-muscles.

a. a. The divided portions of the mantle; *b. b.* Sheaths of the tentacles; *c. c.* The funnel; *d.* Its valve; *e. e.* Shell-muscles; *f. f.* Their terminations or surfaces of attachment; *g.* The transverse fibres connecting them.

VII.—Foraminifera from the London Clay of Sheppey.

By Frederick Chapman and C. Davies Sherborn.

In the Proceedings of the Geologists' Association for 1878,[3] Mr. W. H. Shrubsole, F.G.S., published a list of Foraminifera obtained from the London Clay of Sheppey. The following list, the result of an examination of some material courteously lent to us by Professor J. W. Judd, F.R.S., adds considerably to the fauna of Sheppey and includes two species not previously recorded from the London Clay. Forty-one forms have been determined, of which twenty-six[4] are new to Sheppey, thus bringing up the number of forms recorded from that locality to eighty-six. The geographical distribution of the Foraminifera of the London Clay was fully tabulated in 1886,[5]

[1] Synopsis of the Carboniferous Limestone Fossils of Ireland, 1844.

[2] United States Geol. Survey of the Territories, 1876, vol. ix. p. 490.

[3] Proc. Geol. Assoc. vol. v. no. 7, p. 355, 1878.

[4] Numbers 4–9, 11, 13–15, 19–23, 26–30, 33, 36–41, of the list appended.

[5] Sherborn and Chapman, Journ. R. Microsc. Soc. [2], vi. 1886, p. 759; and *ibid.* 1889, p. 483.

and it is interesting to find so many of the forms there figured and recorded for the first time from the London area common to both localities. The figure following the specific name in the list appended shows the relative abundance of the varieties found.

The two forms deserving mention as new to the London Clay are: *Pleurostomella alternans*, Schwager, Novara Reise, 1866, p. 238, pl. vi. figs. 79 and 80; H. B. Brady, Rep. "Challenger," 1884, p. 412, pl. li. figs. 22 and 23; *Pleurostomella eocæna*, Gümbel, Abh. k.-bay. Ak. Wiss. vol. x. 1868, p. 630, pl. i. fig. 53. A single small specimen, slightly broken on one side, but preserving all the characteristics of the genus.

Lagena desmophora, Rymer Jones. *L. vulgaris*, var. *desmophora*, Rymer Jones, Trans. Linn. Soc. vol. xxx. 1872, p. 54, pl. xix. figs. 23, 24; *L. desmophora*, H. B. Brady, Rep. "Challenger," 1884, p. 468, pl. lviii. figs. 42 and 43. Characterized by prominent decorated costæ, the intercostal areas being occupied by one or more costæ, less prominent and unornamented. One specimen precisely corresponding to figure 42 in Brady's report cited above. Four species of Ostracoda were found, of which two are apparently new.

The following is a list of the Foraminifera:—

1. *Miliolina trigonula*, Lam. sp. 6.
2. *Ammodiscus incertus*, d'Orb. sp. 3.
3. *Textularia agglutinans*, d'Orb. 13.
4. *Bigenerina capreolus*, d'Orb. sp. 14.
5. *Gaudryina pupoides*, d'Orb. 10.
6. *Clavulina communis*, d'Orb. 7.
7. —— *parisiensis*, d'Orb. 2.
8. *Bulimina affinis*, d'Orb. 2.
9. *Pleurostomella alternans*, Schw. 1.
10. *Lagena globosa*, Mont. sp. 1.
11. —— *desmophora*, Ry. Jones. 1.
12. —— *marginata*, Walk. & Boys. 1.
13. *Nodosaria radicula*, Linn. sp. 3.
14. —— *humilis*, Roem. 9.
15. —— *longiscata*, d'Orb. 16.
16. —— *soluta*, Reuss, 4.
17. —— *raphanus*, Linn. sp. 1.
18. —— *badenensis*, d'Orb. 2.
19. —— *polygona*, Reuss, 5.
20. *Dentalina communis*, d'Orb. 5.
21. —— *consobrina*, d'Orb. 12.
22. —— *spinulosa*, Mont. sp. 10.
23. *Dentalina acicula*, Lam. sp. 2.
24. *Marginulina Wetherellii*, Jones, 27.
25. *Cristellaria italica*, Defr. sp. 1.
26. ——— v. *spinulosa*, Sherb & Chap. 1.
27. —— *cultrata*, Montf. sp. 18.
28. *Polymorphina gibba*, d'Orb. 1.
29. —— *gutta*, d'Orb. 1.
30. *Urigerina asperula*, Cziz. 6.
31. *Globigerina bulloides*, d'Orb. 4.
32. *Orbulina universa*, d'Orb. 1.
33. *Pullenia quinqueloba*, Reuss, 3.
34. *Discorbina rosacea*, d'Orb. sp. 1.
35. *Planorbulina ammonoides*, Reuss, sp. 1
36. —— *complanata*, Reuss, sp. 6.
37. *Anomalina grosserugosa*, Gümb. sp. 4.
38. *Pulvinulina repanda*, Ficht. & Moll, sp. 2.
39. ——— var. *concamerata*, Will. 3.
40. —— *Karsteni*, Reuss. 1.
41. —— *punctatula*, d'Orb. sp. 17.
42. —— *striato-punctata*, Ficht. & Moll, sp. 1.

VIII.—On the Occurrence of the Devonian Ganoid *Onychodus* in Spitzbergen.[1]

By A. Smith Woodward, F.G.S., F.Z.S.

During a visit to Stockholm last spring, Prof. Gustav Lindström kindly permitted the writer to examine the series of remains of Palæozoic fishes obtained from the Devonian of Spitzbergen by Dr. A. G. Nathorst, during the Swedish Geological Expedition in 1882. Some of the more prominent specimens have already been briefly noticed, with figures, by Prof. Ray Lankester;[2] but the

[1] Read before Section C (Geology), British Association, Newcastle, 1889.

[2] E. Ray Lankester, "Report on Fragments of Fossil Fishes from the Palæozoic Strata of Spitzbergen," Kongl. Svenska Vetensk.-Akad. Handl., vol. xx. (1884), No. 9, pp. 1-6, pls. i.-iv.

collection is worthy of a more detailed comparative study than that to which it has hitherto been subjected, and among the undescribed specimens most readily identified is a small fossil indistinguishable from the so-called "intermandibular arch" or "presymphysial bone" of *Onychodus*.[1] Through the kindness of Prof. Lindström, this specimen has been forwarded to the British Museum for examination, and it forms the subject of the following remarks.

Four fractured teeth are exhibited, attached in close series to a narrow arched base, and the fossil is firmly imbedded in a hard matrix. It is evidently imperfect, but the base preserved is 0·005 in length, and the uppermost and longest tooth has a nearly similar measurement. This tooth is slender, tapering, and gently curved, without any sigmoidal twist; and both it and the more imperfect teeth below are characterized by the relatively enormous size of the internal cavity.

In its small dimensions the presymphysial dentition from Spitzbergen most nearly approaches that of *Onychodus anglicus*,[2] from the Lower Old Red Sandstone Passage Beds of Ledbury, Herefordshire; but it is distinguished by the more uniformly tapering character of the teeth, and the relatively larger size of the pulp-cavities. In the latter feature it seems to be more nearly paralleled by the much larger, typical species from the Devonian of the United States; but all described forms differ from the new fossil in the larger size of the teeth in proportion to their base of attachment. The Spitzbergen species, thus imperfectly indicated, may therefore be regarded as hitherto unknown, and, in reference to its interest from a distributional point of view, may be named *Onychodus arcticus*.

NOTICES OF MEMOIRS.

THE GEOLOGY OF DEVON, FACTS AND INFERENCES, FROM THE PRESIDENTIAL ADDRESS TO THE DEVONSHIRE ASSOCIATION. By W. H. HUDLESTON, Esq., F.R.S., Sec.G.S., etc. August, 1889.

WE can have little doubt that this South-western part of England had the honour of leading off the Geological Surveys of the world because of its great metallic wealth, and because of the interesting and complicated phenomena associated therewith. But it must not be supposed that the early Surveyors settled every question fifty years ago, especially when we bear in mind the varied nature of the region, the obscurity of many of the problems, and the comparative novelty of the task. Devonshire especially has been the theatre of many a geological battle since then, nor can we aver that the temple of Janus is at present closed. It is twenty-one years ago, I believe, since a President of the Devonshire Association dealt with any of these topics from the chair. Mr. Pengelly, in the year 1868, after giving an admirable summary of

[1] J. S. Newberry, Geol. Survey of Ohio, vol. i. pt. ii. (Palæontology), pp. 296–302, pts. xxvi. xxvii.

[2] Smith Woodward, "Note on the Occurrence of a Species of *Onychodus* in the Passage Beds of Ledbury," GEOL. MAG. Dec. III. Vol. V. (1888), p. 500.

the progress of geology in Devonshire up to that date, propounded nine questions for special consideration in the future. These I venture to recall to your memory—

1. The age of the crystalline schists of the Bolt.
2. The precise chronology of our Limestones and associated rocks.
3. Is there east of Exmouth a break in the Red rocks?
4. Whence come the Budleigh Salterton pebbles?
5. Whence also the porphyritic trap nodules so abundant in the Trias?
6. Are our Greensands really of the age of the Gault?
7. Whence the flints so numerous in our existing beaches?
8. What is the history of our superficial gravels, and are there any indications of glaciation in Devonshire?
9. To what race did the Cave-men belong?

During the interval of over twenty years most of these questions have been discussed, often by Mr. Pengelly himself, and the records are to be found in the volumes of your *Transactions*. Confining any remarks I may have to make on the present occasion to points bearing on the physical history of the county, I would say that these questions may be grouped under five heads—(1.) Recent and Pleistocene geology; (2.) The extent and nature of the Cretaceous rocks; (3.) The New Red question; (4.) The Old Red question; and lastly (5.) The age of the crystalline schists, to which may be appended any necessary remarks on petrological questions.

Recent and Pleistocene Geology.

The recent geology of the county is famous, as all the world knows, for the occurrence of raised beaches, submerged forests, and bone caves. On these I scarcely venture to touch, the cave-question especially verging on the confines of archæology. If the caverns at Oreston were first made the subject of scientific enquiry, those of Kent's Hole and Brixham have yielded results of surpassing interest. Going a step further back in time, there are few problems more obscure than the history of the plateaux gravels of the southern counties: these consist largely of flint. Mr. Parfitt, speaking of the drift gravels towards Dawlish, has expressed his opinion that the agents producing these were ice and water. To this we can scarcely demur, but it was hardly necessary to have included Devonshire in the ice-sheet. The indications of glaciation in this county are matters of inference rather than self-assertion, and observers, like Mr. Somervail, accustomed to the marked features of a thoroughly glaciated country, are slow at finding any evidence of it here. Still it must be obvious to all who reflect upon the subject that the cold which has left such enduring evidences of its intensity in areas so near, for instance, as Caernarvonshire, must have affected the Devonshire climate to a considerable extent. The absence of true Boulder-clay should reconcile the Devonian to the fact that his country is destitute of cowslips, which are very partial to the Boulder-clay soils of the North of England, and are far from scarce in the heavily-bouldered regions of East Anglia. It is true that the

Swedish botanist Nathorst, speaking of the peculiar mixture of clay and stones known as the "'Head' of Bovey Tracey," called it Boulder-clay; and Mr. Pengelly likewise mentioned lately that another Scandinavian authority, Dr. Torell, when in company with Mr. Ormerod as long ago as 1868, professed to have detected three moraines on Dartmoor in the neighbourhood of Chagford. That these were the results of an ice-cap, as that term is generally understood, I do not regard as probable; but bearing in mind the recorded facts, and also the frequency of such features as "terminal curvature," we may well believe with Mr. Worth in the existence of something like a local snow-cap on the higher grounds. The peculiar nature of the cave-breccia, and the Arctic character of some of the cave-animals, also point in the direction of a colder climate. Not that this evidence is really required, except as a matter of corroboration. We may believe, then, in a glaciation so modified that its results require close search before they can be appreciated.

The Extent and Nature of the Cretaceous Rocks.

There are few problems in the physical history of the South-west of more interest than this. Speaking of the geology of the neighbourhood of Dawlish, Mr. Ussher says there can be little doubt that the Cretaceous highlands of Devon, such as the Haldons, are portions of a great plain of marine denudation, and he speaks of a time when that Cretaceous tableland abutted on the flanks of Dartmoor. He also refers to the presence of flints in the old and more modern gravels as evidence of the extension of Chalk *débris*. It is interesting to know that abundant fossil evidence of the former existence of Middle Chalk (the Upper Chalk of some writers) is found in the chert and flint beds which form the capping of Little Haldon; the Echinodermata are especially characteristic. Mr. Ogilvie Evans has called attention to this fact.

As regards the former extension of the Chalk, I see no reason to doubt that the western part of what is now the Channel and the greater portion of Devonshire and Cornwall were submerged beneath the Chalk Sea. It seems to me that in no other way can you account for the quantity of flints on the western beaches and in the bottom of the Channel. But, irrespective of this corroborative evidence, one would expect the Chalk Sea to have extended in this direction. Then comes the question, Was there any western limit to the Chalk Sea, or did its waters mingle freely with the Atlantic Ocean during the period of extreme depression? At the epoch when the Upper Greensand, or basal sediment of the Chalk, was being laid down, Mr. Jukes-Browne, in his "Building of the British Isles," represents the extreme western shore-line, plotted on the existing map of Devon as passing from the Ermemouth towards the Haldons; *i.e.* roughly parallel to the E.S.E. flank of Dartmoor. Now the distance from the Ermemouth to the present edge of the deep Atlantic basin is about two hundred miles, and that two hundred miles would represent the width of the land which intervened between the Upper Greensand Sea and the Atlantic Ocean at the

particular period indicated in the hypothetical map to which I have referred. It is a question for separate consideration whether that intervening space of land was wholly or only partially submerged at a later epoch during the period of extreme depression. For our purpose it will be sufficient to have carried the western margin of the Chalk Sea beyond the limits of the Cornish peninsula during the period of lowest depression, and this I think we may fairly claim. I ought to observe that it is not assumed that the English Channel had any existence at that time. Mr. Jukes-Browne regards the Channel as a very modern feature in physical geography, but the existence or non-existence of the Channel as a mere excavation will hardly affect the question of the westward boundary-line of the Chalk Sea.

One more question of Mr. Pengelly with reference to Cretaceous geology remains, viz. the age of the Devonshire Greensand. It was Fitton, and after him Meÿer, who maintained that the Blackdown Beds were of Lower Cretaceous age, although before their time De la Beche had classified them as Upper Greensand, whilst Godwin-Austen described them as possibly a sandy condition of the Gault. The littoral facies and abundance of *Trigoniæ*, having considerable resemblance to Lower Greensand species, led Mr. Meÿer astray. Dr. Barrois and other authors entered the lists, and when Mr. Downes read his excellent paper before the Geological Society in 1881, the balance of opinion tended to the view that the Gault, or most of it, is represented in the Blackdown Beds, and that seemed also to have been Mr. Downes' opinion. If the Ammonites in that gentleman's collection have been correctly determined, there would seem to be a mixture of Lower-Gault with Upper-Gault forms; but as the Upper-Gault of the East of England is represented to a considerable extent in the West by the Upper Greensand, it follows that, if we allow most of the Gault to be represented in the Blackdown Beds, such a determination carries the Upper Greensand with it, so that both De la Beche and Godwin-Austen were right.

There is not a trace of Lower Greensand, and when we bear in mind that the Lower Greensand has already disappeared to the eastward, its revival at Blackdown would be an anomaly. But a further argument in this direction, which Mr. Downes, aided by Mr. Vicary, was the first to indicate, is derived from the fact that the nine lowest horizons indentified at Blackdown are missing at Haldon. This proves conclusively that the basal rocks of the Upper Cretaceous ever occupy a higher horizon as we proceed westwards, and, as we have already seen, this has an important bearing on the question of the final westward limit of the Chalk Sea. It is quite possible also that the missing beds of Chalk were more siliceous than their equivalents further eastwardly, and this would still further help to account for the flints so numerous in the Channel and adjacent shores.

There are two points in connection with Blackdown which might be mentioned: 1st, Mr. Downes read a paper before the Geological Society in November, 1884, "On the Cretaceous Beds of Black

Venn, with some supplementary remarks on the Blackdown Beds." There he appeared to arrive at the conclusion that the *Lima-parallela*-bed of Black Venn is lower than the lowest of the Blackdown Beds, for it thins out before reaching Sidmouth. He again notices the general thinning out westwards. These latter conclusions are somewhat at variance with his previous ideas that the Blackdown Beds represent the whole of the Gault, and he finally inclined to the opinion that the Blackdown Beds were Upper Greensand rather than Gault. I have before pointed out that the Upper Greensand partly represents the Upper Gault of the south-east of England, and this interpretation will help to explain the apparent contradiction.

2nd. The mode in which the clumps of *Turritella* and *Pectunculus* occur in the Blackdown Beds reminds me of the similar way in which their modern representatives occur in the English Channel. Not far from Hope's Nose is a muddy bed full of *Turritella*, showing how the shell is apt to accumulate from some cause or other in one or two particular spots, and throughout the Channel it is by no means uncommon to come across *Pectunculus* in great numbers at particular spots.

New-Red Beds.

The New-Red question next demands our attention, since the Jurassic rocks of Devonshire are limited to a very narrow strip of Lias in one corner of the county. The phenomena in connection with the New-Red beds are of great interest in spite of their poverty in organic remains. We are as much interested in the composition of these beds as in ascertaining their precise chronological value. Thus two of Mr. Pengelly's questions relate to the composition of Triassic pebble-beds. It would certainly appear from Mr. Davidson's determination of the Brachiopoda that a considerable portion of the Budleigh-Salterton pebbles were of Devonian origin or aspect, although there are a sufficient number of admitted or possible Silurian species. Thus Salter's original proposition that they are Normandy types of the May-Hill Sandstone may in part be correct, the fossils being characteristic of beds on both sides of the Channel. The rocks from which such pebbles were derived are certain to be no longer in existence; the pebbles themselves are mere survivals of an ancient denudation, just as is the case with the flint pebbles whose origin we have lately been considering. It is not difficult to believe that both Silurian and Devonian beds were largely developed in portions of what is now the Channel area. Indeed the form of the present peninsula of Normandy clearly points in that direction, whilst projections of Palæozoic rock from what is now the Devon-Cornwall peninsula may likewise have contributed their share. Hence an extension of the Gorran Haven beds, or of La Manche, points almost equidistant, may have been amongst the missing rocks from whose hardest parts some of these pebbles were long ago torn. There is no evidence, so far as I am aware, that the English Channel, in anything like its present form, had any existence in Mesozoic times, and we may well believe this without going so far as Mr.

Jukes-Browne, who represents the English Channel as merely a feature of Pleistocene geography. Doubtless the origin of the English Channel is a problem well worthy the attention of Devonshire geologists, but at present we are considering the composition of Triassic pebble-beds, and must not, therefore, allow ourselves to be led off on a false scent.

Mr. Pengelly's other question, as to the origin of the porphyritic trap nodules, is one which embraces a far wider scope; for along with it must be considered the subject of igneous fragments in the New-Red generally. One would be disposed to say that most of them were derived from the felspathic traps, so many of which make their appearance at the junction of the Carboniferous and New-Red. This peculiarity of position Mr. Vicary was disposed to attribute to the circumstance that these traps have served to arrest denudation in the Trias. It is said that none are to be seen in the coast section. Mr. Vicary regarded the earliest eruptions of this class of rock as having taken place between the close of the Carboniferous and the commencement of the Triassic, whilst the latest outbursts were of Triassic age. Mr. Downes also, whilst endeavouring to account for the presence of some Upper Devonian fossils in the Trias near Tiverton, has expressed his opinion that the hypothesis of an active volcano upon the coast of the early Triassic sea best meets the requirements of the case. Mr. Somervail likewise has expressed his views on the probable volcanic origin of the breccias at the base of the Trias in South Devon, and as to the conditions prevailing during their accumulation.

It cannot be doubted that a careful and unprejudiced study of the igneous rocks in the Devonshire Trias will help to throw much light on an important stage in the physical history of the area. But in undertaking such an investigation due allowance must be made for the changes which the fragments have themselves undergone in a highly permeable formation. If lumps of hard limestone, under the influence of siliceous infiltration, have been converted into that peculiar form of orbicular silica known as "Beekite," we need not be surprised at felspars, derived originally from Dartmoor, having been converted into Murchisonite, which chemically differs from orthoclase mainly in containing somewhat more alumina.

And thus it came to pass that pieces of Dartmoor granite were unrecognizable, whilst a generation of geologists, following De la Beche and Godwin-Austen, were disposed to believe that during the New-Red epoch, the granite of Dartmoor had not as yet reached the surface. Lately, speculation has taken quite a different turn. Mr. Worth is disposed to think that the granite of Dartmoor passed upwards into felsitic and volcanic rocks, remnants of which, he says, are to be found in the Triassic conglomerates of the county. Geologists, therefore, having started with the belief that the Dartmoor granite was covered up by sedimentaries in Triassic and pre-Triassic times, are now presented with a picture of a pre-Triassic volcano towering into the skies. It is also intimated that andesites and specimens of volcanic grit such as arise from the denudation of volcanic cones have been found in much more recent deposits.

Confining our attention for the present to the New-Red rocks, one would suppose that if the above speculations have a good foundation, the evidences of volcanic rocks derived from the disintegration of the old Dartmoor volcano ought to have been much more abundant in the Triassic conglomerates than they have hitherto seemed to be. But the further investigation of this matter must be deferred until we have considered the chronology of the New-Red beds.

We now perceive the import of the question put by our propounder of riddles, "Is there east of Exmouth a break in the 'red rocks'?" So recently as 1881 Mr. Pengelly wrote: "I incline to the opinion that our Red Rocks, taken as a whole, belong to the Keuper; or, if not, that all three sub-systems of the Trias are represented in Devon." Of course, when Mr. Pengelly thus infers the existence of the middle member of the Trias, he can only mean that the Muschelkalk is represented in time.

Mr. Ussher, four years previously, had given in the Transactions of the Association the results of his experience in the classification of the Triassic rocks. His view was that whilst in the Midlands there is complete unconformity between the Bunter and Keuper, in Devonshire the Triassic beds present a conformable series. He also showed that the beds cut out at Straight Point and Exmouth, in the south-coast section, are visible in the inland districts, thus practically answering Mr. Pengelly's question in the negative. The once prevalent notion, therefore, that the whole of the Devonshire Trias is of Keuper age, a notion which seemed to have the support of high authority, must be abandoned. A series of marls and sandstones, called by Mr. Ussher "Middle Trias," he thought might roughly represent the Muschelkalk in time, whilst his "Lower Trias," consisting of sandstones and breccias with igneous fragments, so well developed between Dawlish and Watcombe, is mainly of Bunter age. The older beds would presumably occur to the westward, but there does not seem at this time to have been a suspicion of Permian on the part either of Mr. Ussher or Mr. Pengelly. Mr. Ormerod, in his notes on the deep borings in the Trias at Teignmouth, also describes the beds between the Exe and the neighbourhood of Torquay as belonging to the Bunter.

In a communication to the Geological Society Mr. Ussher speaks of the lowermost beds of the south-coast Trias as far exceeding their more northerly equivalents in thickness, and as affording a strong probability that a reconstruction of the English Channel valley would exhibit a still greater development of beds, dating as far back perhaps as late Permian times. It is thus evident that Mr. Ussher considers that a large extent of New-Red rock has been destroyed in the formation of the English Channel, and possibly portions may yet be proved in the bed of the Channel itself. Mr. Worth, as you know, considers that he has evidence of the existence of Triassic rocks *in sitû* fifty miles to the south-west of the Triassic outlier at Cawsand, in Plymouth Sound, but it is rather a peculiar feature in this case, that the supposed submarine Trias resembles the Keuperian or eastern variety of the Devonshire Red Rocks. Mr.

Irving, who has paid some attention to these questions, differs from Mr. Ussher, and still more from Mr. Pengelly, in the belief that the breccia series is of Permian age. He regards it, in fact, as the result of terrestrial and littoral deposits on the flanks and on the shore-line of the old mountain region of which the Devon-Cornwall peninsula is one of the remnants, the high inclination of the dip being in favour of its being mainly composed of mountain detritus.

It would be difficult indeed to assign any other origin to the wonderful group of beds which constitute the sea-cliff between Teignmouth and Dawlish. The only matter in dispute is the precise chronology of these beds. Shall we say with Mr. Pengelly that they are of Keuper age? or with Mr. Ussher and Mr. Ormerod, that they are of Bunter age? or shall we agree with Mr. Irving that they are of Permian age? In the absence of marine mollusca the precise age of any series of beds is difficult to determine; all that we can affirm with absolute certainty is that they belong to the Permio-Triassic interval, and that in this country such beds are more usually Permian than Triassic. The brecciated beds of the Leicestershire Permians, for instance, have been recently shown to be composed of the re-arranged talus of the harder portions of the Palæozoic rocks surrounding that part of the old Permian lake.

The Post-Carboniferous Interval.

Leaving the question of the actual chronology of the Dawlish beds as almost hopeless in our present state of knowledge, we must be content to bear in mind the main facts of the case, viz. that towards the close of the Carboniferous period one of those great shifts in the earth's crust occurred, of which there have been three or four during geological time. Roughly speaking the Palæozoic epoch terminated with this great movement, whose flexing action has, in the main, governed the axes of the series of synclinals and anticlinals existing between the Bristol and English Channels, with an extension towards the south so as to include the peninsula of Brittany. The principal of these earth-throes occurred during the unrepresented period of time which intervened between the Coal-measures, as usually developed, and the Permian; and though there are evidences of subsequent oscillation in our district to a moderate extent, no instances of folding and contortion occur in the beds deposited afterwards. Then it was that the building of the British Isles commenced in earnest, and that the first rude sculpturings of the future Devonshire were made. Some of these points we shall have to consider again in reference to the general structure of the county.

The Carboniferous.

Before proceeding to answer the remainder of Mr. Pengelly's questions, a few words may be devoted to a formation which in Devonshire is both extensive and disappointing. No attempt will be made to correlate any portions of these beds wih their presumed equivalents on the Welsh side. All we can say is, that

the Old-Red of the Welsh border does not differ from the Devonian of Devonshire more than does the Carboniferous of Wales from beds of the same system in this county. The Culm-measures are something *sui generis*, and it seems difficult to account for their origin.

It may be worth mentioning in this connection that Dr. Barrois, speaking of the physical history of Brittany, which presents certain analogies with that of our south-western peninsula, observes that the Carboniferous period in that region was one of oscillation between terrestrial and marine conditions—a period of extensive eruptions and great earth movements. Hence he says that a considerable portion of the sediments, especially towards the base, are of volcanic origin. This is not at all the case with the Carboniferous in North Devon, where the sequence is undisturbed. According to the views generally accepted, the main horizon for contemporaneous igneous rocks in the Palæozoic of Devonshire lies in the Lower Devonian, though there seems to be some difference of opinion upon this point.

The Old-red or Devonian Question.

This may with justice be termed the home question; but in order to attempt a solution, it will be found necessary, in the first instance, to take into consideration the Old-Red Sandstone of other areas. The claim of the Devonian to recognition as one of the great geological systems has been challenged more than once; and even when this has not been disputed, there have been divers contradictory efforts to fit in the marine Devonians with the several members of the Old-Red Sandstone. In North Devon the matter was further complicated by the great Jukesian heresy, based on the alternative supposition of a concealed anticlinal with an inversion towards the north, or more probably an east and west fault. These ideas, as you know, were successfully combated by Mr. Etheridge and Mr. Townshend Hall in the earliest days of the Association; and about ten years ago the latter gentleman reviewed the history and classification of the North-Devon Rocks in an able paper which appeared in the "Transactions." His own classification of the North-Devon beds differs in details from that adopted by Ussher and Woodward; but this is a matter of minor importance, since all agree in regarding the Ilfracombe limestones and associated slates as a definite central datum line, from whence to proceed either above or below. Mr. Hall observes that the North-Devon beds from Lynton to Pilton, though preserving a general dip to the south, are folded into many anticlinals, reducing their apparent thickness very considerably.

Having got the North-Devon beds, which are really the key to the whole Devonian system, into something like order, it now becomes necessary to quit the county for a while in order to study the Old-Red Sandstone on the other side of the Bristol Channel. And here we realize the fact that there are two Old-Red Sandstones, the Lower of which is perfectly conformable with and passes down into the underlying Silurian, whilst the Upper passes conformably into the Carboniferous, of which system, in a certain sense, it may

be regarded as the base. It is only in recent years that this unconformity between the Lower and Upper Old-Red Sandstone has been fully recognized. Moreover, this is by no means a local phenomenon confined to the Welsh districts, since in the South of Ireland there is a great hiatus between the presumed equivalents of the Pickwell Down beds above and those of the Lynton beds below. Thus both in the South of Ireland and in South Wales the time representatives of the Ilfracombe and associated beds are absent. These three districts are more or less involved in the great post-Carboniferous east-and-west folding, and may be said to belong to the same system of physical disturbance. But even in Scotland Hugh Miller's Old-Red Sandstone is found to consist of two portions, the lower part shading off into Silurian, the upper into the Carboniferous. Thus, throughout the British Isles, what was formerly known as the Old-Red Sandstone is found to consist of two very distinct members, widely separated from each other in point of time, each having affinities with the neighbouring system. If, then, the case rested on the Old-Red Sandstone alone, its fate would only differ from that of Poland in being partitioned between two instead of three ambitious neighbours.

Having learnt thus much with regard to the Old-Red Sandstone, it is now time to return to North Devon, where we have a fossiliferous series interposed between beds which are held to be the equivalents, *mutatis mutandis*, of the Lower and Upper Old-Red Sandstone respectively. It is these fossiliferous beds which forge the link that was missing, whilst the intermediate yet independent character of their fauna justify, on palæontological grounds, their being regarded as the head-quarters of a distinct and separate system. The more copious development of the remains of marine organisms in the corresponding beds of South Devon further justify the original determinations of Lonsdale. It is these central beds, therefore, which constitute the backbone of the Devonian system; and if the correlations to which I have alluded be substantiated, they must carry with them the Upper and Lower Old-Red Sandstone as integral parts of that system.

It seems to be generally admitted that the Pickwell-Down beds are really the equivalents of the Upper Old-Red Sandstone. Perhaps it was Professor Hull who first suggested this, but nearly ten years ago Mr. Champernowne, whilst agreeing that the Pilton and Marwood beds should be referred to the Carboniferous, considered the Pickwell-Down Sandstone to be true Old-Red Sandstone, and also Upper Devonian. The fact of the Pickwell-Down beds being unfossiliferous lends additional probability to this view. The correlation of the lowest Devonian beds with the Lower Old-Red Sandstone seems more open to discussion. In the first place the subject is complicated by the suggestion that the Foreland and Hangman Grits are repetitions of the same beds by means of faulting, and secondly the arenaceous beds of the Lower Devonian in North Devon yield some marine mollusca. The resemblance of the Foreland Sandstones to the Glengariff Grits was regarded by

Professor Hull as most striking. On the whole there still seems a little obscurity as to the details of the lowest Devonian beds on the Bristol Channel.

There would be no use in considering the Devonian sequence in South Devon until that in North Devon had been fairly settled. It is not always that opportunities are afforded for studying a set of beds in duplicate within a limited distance, but I have had occasion to notice, more than once, the very great differences of development that present themselves under such circumstances within areas not so very far apart. Doubtless the original differences were very considerable, since South Devon must be regarded to a certain extent as a reef region, and the beds moreover were largely reinforced by contemporaneous volcanic matter of a basic nature, from which the equivalent beds in the North Devon area were almost entirely free. But in addition to these congenital elements of difference are others belonging to a subsequent period, such as a further extravasation of igneous rocks, and above all the extraordinary folding and compression to which the beds have been subjected. The confusion is something terrible, and we may regard the district as practically unmapped, although, thanks to Mr. Champernowne and others, a certain amount of correlation with the North Devon beds bas been established.

The backbone of the system is constituted by the Great Devon and Plymouth limestones with their associated upper and lower slates, the upper or Dartmouth slates more especially corresponding with the Morte slates of North Devon. Underlying these central beds, or Middle Devonians, are the Torquay Grits, containing the *Homalonotus*-beds, some of which struck Mr. Champernowne as being suspiciously like certain Ludlow rocks. These of course are naturally correlated with the Hangman Grits and Lynton Slates. Whether beds as low, or even lower than these, occur in any other part of South Devon, I am not in a position to state; but the beds of Yealmpton Creek have been placed on this horizon, and some geologists have even spoken of Silurian beds in the country north of Tavistock. On the other hand, the Upper Devonian, according to Mr. Champernowne, is represented by the Cockington Grits, originally described by De la Beche as Old-Red Sandstone, and these are the equivalents of the Pickwell-Down beds of North Devon. For Mr. Champernowne the Upper Devonian would appear to terminate with these beds, which he correlates with the *Psammites du Condroz*. Mr. Ussher, in describing the relations of the Devonian and Culm rocks on the east side of Dartmoor, observes that, as a rule, the Upper Devonian rocks occur in faulted association with the basement-beds of the Culm-measures. But in the area between Bovey Tracey and Bickington the uppermost Devonian beds are irregular slates, similar to the Pilton beds, and in one or two unfaulted junctions they pass up into Culm-measures, which are overlain by indurated shales of the Coddon Hill type. These recent observations of Mr. Ussher would seem to complete the analogy between the Devonian rocks in North and South Devon.

It would be beyond the limits of a Presidential Address if I were to follow this very interesting subject much further on the present occasion. I hope to have demonstrated that considerable progress has been made with the Devonian question during the last twenty years, although, as stated by Mr. Whidborne, in his preface to the "Devonian Fauna of the South of England," the correlation of the different parts of the system with the major divisions in America and the Continent is still a matter of discussion. Crumpled up and reversed as the beds are in South Devon, their stratigraphy will always be complex; but it is probable that in their original condition there was considerable resemblance to the Rhenish and Belgian Devonians, pointing to the prevalence of fairly similar conditions during the period of deposition.

Referring to the subject of correlation with Continental beds, there is an article in the "Neues Jahrbuch" for the present year "On the Devonian of Devonshire and the Boulonnais," written by Herr Kayser, which, he says, is the outcome of a trip to the South-west after the Geological Congress of last autumn.

Herr Kayser finds in South Devon a development which intimately approaches the West-German. In the Upper Devonian of that region he recognizes nodular limestones with *Clymenia* (more typically developed at South Petherwin), "*Cypridinen*-schiefer," Adorf Goniatite-limestone, Büdesheim-shales, and Iberg Coral- and Brachiopod-limestones. In the Middle Devonian he recognizes *Stringocephalus*-limestone, *Calceola*-limestone, *Calceola*-shales, and possibly also Goslar-beds. In the Lower Devonian he finds the Upper and Lower Coblenz stages and "Siegen-Grauwacke" especially represented by a small but typical fauna at Looe. This general agreement is further increased by the appearance of numerous "greenstones," which, just as in Nassau and the Harz, are accompanied by schalsteins.

He notes the difference of development in North Devon. In the Upper Devonian the *Clymenia*-limestone, the Adorf Goniatite-limestone, and the Iberg coral-limestone are missing. In the Middle Devonian he notes the absence of the great *Stringocephalus*- and *Calceola*-limestones of South Devon. The Lower Devonian of this area, with its preponderance of hard quartzitic sandstones and grauwackes, does not for the present permit of any close comparison with the Rhenish or Belgian-French Devonian. He recognizes the horizons of the Pilton beds and of the *Cucullæa*-zone, or Baggy beds, which seem to have their Continental analogues rather in Belgium than on the Rhine, but there is nothing in those countries to represent the Pickwell-Down Sandstone. So likewise the phyllitic shales of Morte and Ilfracombe, which alone represent the whole Middle Devonian of North Devon, are equally without analogues.

From the above we may fairly conclude that the North-Devon beds have very little in common with the Devonians on the Continent. But it is mainly through the North-Devon Beds, as we have already seen, that the Devonians generally can be made to fit in with the two members of the Old-Red Sandstone. Both geographically and in character the North-Devon beds occupy an intermediate

position between the calcareous-volcanic Devonians of the South and the coarse quartzose sediments of the Welsh border, altogether devoid of mollusca. If we regard the "Old-Red" of South Wales as an inshore deposit over an area which was deluged with fresh water from off the land, we can believe that further out to sea, in the times of the Lower Old-Red, conditions were favourable for a moderate amount of marine mollusca. This does away with the necessity for a barrier, and also, in a general sense, it suggests a kind of gradation between the Old-Red, the North Devon, and the South Devon deposits.

Bolt Rocks, etc.

The age of the crystalline schists of the Bolt.—Besides the mere chronology of the subject, there are questions of considerable interest in connection with these schists, the consideration of which more or less involves the physical history of the bed of this part of the Channel, as well as of the adjacent lands. In this connection also we may endeavour more especially to review the physical structure of the entire South-west, to which allusion has already been made in reference to the effects of the great post-Carboniferous disturbance so obvious throughout Devonshire.

The subject generally is by no means ripe for final decision, and even if we limit our observations, in the first instance, to the Bolt Rocks and their submarine connections, real or supposed, we must allow that, if metamorphism has usually proved an obscure question, the study of metamorphism under water is hampered with additional difficulties. There are no rocks in the county whose age and origin, even to this day, are so much debated as those which, speaking generally, we may term the Bolt Rocks.

Of the numerous theories which have been advanced, the most doubtful, it seems to me, is that which regards the mass as the result of progressive metamorphism from the action of underlying or contiguous submarine granite. Allowing, for the sake of the argument, that there is progressive metamorphism, although Prof. Bonney and Miss Raisin distinctly deny it, there is very little in the chlorite- and mica-schists of the Bolt district which resembles the peculiar fringe of partially metamorphic rock due to contact with a granitic mass. Such fringes are usually marked by abundance of andalusite, amongst their other characteristics, especially when slates are invaded. Yet we do not hear of this mineral in connection with the Bolt Rocks, though it must be admitted that the microscope has revealed the existence of kyanite, hitherto unsuspected.

Let us now for a moment examine the case for progressive metamorphism, which has found a recent advocate in Mr. Somervail. Many of us perhaps, in common with that gentleman, fail to understand why all metamorphic rocks, not absolutely the result of contact action, should be claimed as Archæan. But this unwillingness to accept their Archæan age does not compel us to believe that there has been progressive metamorphism, whereby an extension of the Dartmouth Slates, even with the addition of interbedded igneous rocks, has yielded, under peculiar circumstances, the mica-schists and chlorite-rocks of the Bolt. Mr. Somervail's argument, that the

chlorite rocks are the metamorphic equivalents of interbedded sheets of igneous rock on the north side of the syncline, though ingenious, is scarcely convincing. A series of chemical analyses at this stage of the argument would be useful. On striking the balance of evidence it seems probable that the slaty beds are wholly distinct from the true metamorphic rocks in the south. If reliance is to be placed on the microscope, this must be regarded as proved. I would remark also, that few things are more deceptive than an apparent sequence in a highly compressed region; so that the presence of a fault is more often a matter of inference than of direct observation in such districts.

It is not absolutely necessary for us to believe that the crystalline schists of the Bolt are of Archæan age, if indeed we know exactly what is meant by Archæan. But I think that there are fair reasons for considering them to be older than the Devonian against which they abut; and that, in point of fact, they owe their present position to having been involved in the anticlinal uplift of which there are traces here and there along the channel shores of the Devon-Cornwall peninsula.

And this brings me to the consideration of the general structure of Devonshire from a stratigraphical point of view. Regarded as a whole, every one knows that Devonshire is a broad synclinal. The Lower Devonian beds of Torquay on the one side and of Linton on the other are practically on the same horizon, and, omitting minor curves and breaks, the extensive region between these two points is one great trough of Palæozoic rocks. But if we start again from the neighbourhood of Torquay in the direction of Dartmoor, it is still found that, on the whole, newer beds come to the surface as the south-east flank of the granite mass is approached. No matter how the beds in the immediate vicinity of the granite may be affected, the south-east flank of Dartmoor must be regarded as lying in a depression, relative to the coast rocks at the points already mentioned. Again, shifting our position considerably with regard to the central mass of granite, we find a suspicion of Lower Devonian rocks at Yealmpton, and a certainty of them at Looe, all pointing to the conclusion that there are traces of the northern wing of an anticlinal on the Channel coast. An inner and more deeply-seated portion of this anticlinal, in places resulting in a dislocation and possibly an inversion, has brought up the crystalline schists of the Bolt. With these perhaps may be associated inferentially the gneissic rocks in the neighbourhood of the Eddystone, mixed with other crystalline rocks, such as those mentioned by Mr. Arthur Hunt. But if the submarine granite or granites have had no more effect than that of Dartmoor in uplifting the country, they must be regarded as factors of minor importance in the structure of the Channel anticlinal.

Of course, the probability of an anticlinal axis in the English Channel has long been recognized, and indeed the space between the Devon-Cornwall peninsula and Brittany is wide enough for many a flexure, the mean result being an east-and-west axis of principal uplift, the exact position of which it is impossible to

determine. Taking a wide geographical view of the subject, we cannot fail to see that there is, first of all on the north, the synclinal of the Glamorganshire coal-field; next the anticlinal of the Bristol Channel, both being rather limited in extent. The second and central synclinal is that of Devonshire, somewhat bulged by the mass of Dartmoor. The succeeding anticlinal of the English Channel was, in all probability, of a very complex nature, bringing up to-day many old and curious rocks, more or less injected by granites, of which we now have the evidence in the Channel Islands, to say nothing of the traces in the bed of the Channel itself, such as Mr. Hunt has so often brought to the notice of the Association.

Beyond this mysterious region of the Channel lies the rocky country of Brittany, which, according to Dr. Barrois, is essentially constituted by a vast geosynclinal depression, running from east to west. The flanks of this great basin consist of very ancient rocks, not quite parallel to each other, but converging somewhat towards the west, and opening out towards the east. The area enclosed has numerous secondary folds, and includes a large series of beds from the Silurian to the Carboniferous. In this region also there are granites, but of more than one age, and Dr. Barrois thinks that they have rather a tendency to follow the anticlinal axes.

Brittany, therefore, constitutes our third great synclinal; but in that country a far lower sequence of beds is brought to-day than in Devonshire, proportionate in fact to the much greater area of the country itself. The principal folding movements there also date from Carboniferous times, and thus the entire region, from South Wales to Brittany inclusive, belongs to what we may call the Hercynian system of mountain-making. It is interesting to note that, in the vicissitudes of time, the three synclinal areas still keep their heads above water, whilst the two areas occupied by the anticlinals are submerged—by no means an uncommon geognostic feature. I am not quite prepared to believe that, on this meridian, the so-called Hercynian system ever attained to any great degree of elevation, though undoubtedly of great width. Its degradation has contributed enormously to the Mesozoic deposits, and in a lesser degree perhaps to the Tertiaries of the country to the eastward.

(*To be concluded in the December Number.*)

REVIEWS.

I.—Marine Deposits in the Indian Ocean.

"On Marine Deposits in the Indian, Southern, and Antarctic Oceans." By John Murray, LL.D., F.R.S.E. Scottish Geographical Magazine, vol. v. (1889), pp. 405–436, woodcuts 1–12.

In November, 1887, Dr. John Murray communicated to the Scottish Geographical Magazine an account of the marine deposits in the deeper regions of the Indian Ocean, mainly based upon materials obtained by Captain J. P. Maclear, of H.M.S. *Flying Fish*. Subsequent investigations by Captain Pelham Aldrich in H.M.S. *Egeria*, and Captain A. Carpenter in H.M.S. *Investigator*, in addition to

recent dredgings off the east coast of Africa for the purpose of laying cables, have furnished the author with ample means for extending the results formerly attained; and, on the present occasion, Dr. Murray ventures to map the area described, carefully marking all the points from which sediment has actually been examined, and those from which sufficient material has been obtained for a chemical and microscopical analysis. The map "represents the Indian Ocean and those portions of the Southern and Antarctic Oceans between the meridians of 20° and 150° E., and is estimated to contain 27,600,000 square miles." In this area, 415 reliable soundings in depths of 1000 fathoms and upwards are available for study and comparison; and the descriptions and conclusions detailed in the memoir before us form an important addition to the quota of information concerning marine sediments already placed by Dr. Murray at the disposal of geologists.

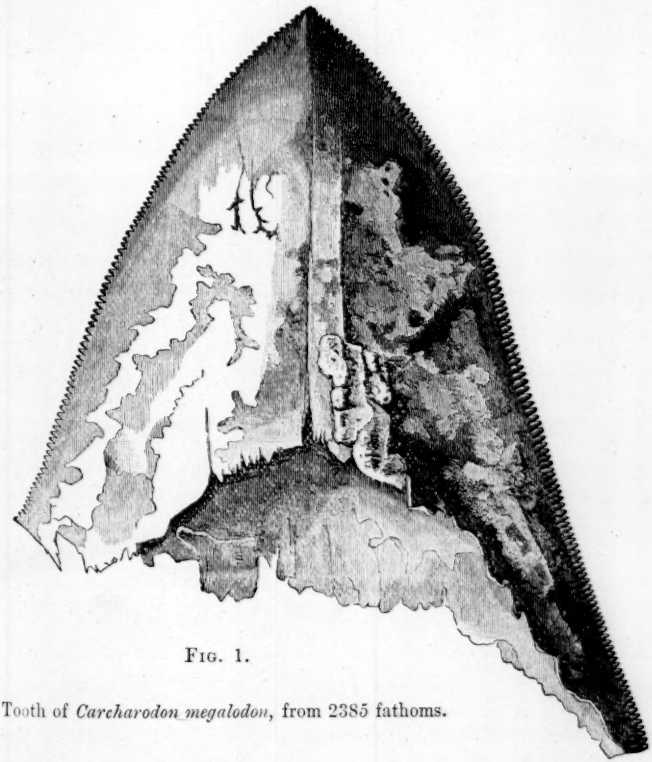


Fig. 1.

Tooth of *Carcharodon megalodon*, from 2385 fathoms.

"Beyond the 1000-fathom line there is a gradual deepening from the shore, extending southwards and eastwards, the deeper soundings being found in the eastern portion of the region under consideration. The deepest part is, indeed, situated between the equator and the

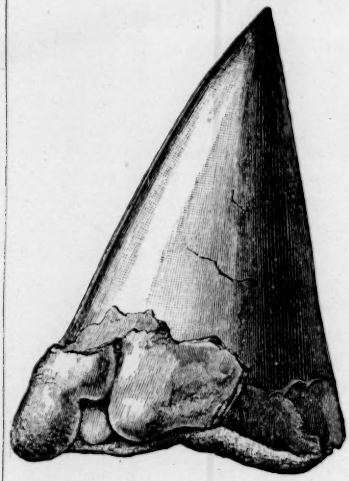


FIG. 2.—Tooth of *Oxyrhina hastalis*. From 2350 fathoms.

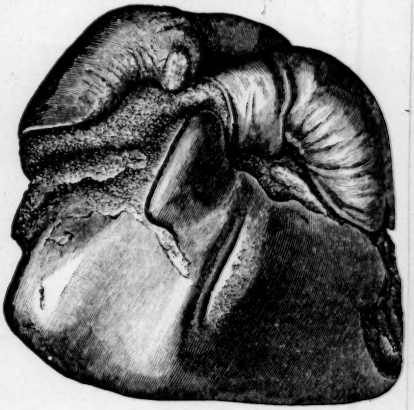


FIG. 3.—Ear-bone of *Ziphius cavirostris*. From 2335 fathoms.

FIG. 4.—Section of a Manganese Nodule, showing ear-bone of *Mesoplodon* in the centre. From 2600 fathoms.

FIG. 6.—Spherule of Bronzite. From 3500 fathoms. (× 25.)

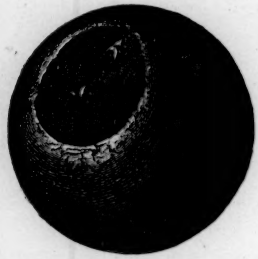


FIG. 5.—Black Cosmic Spherules, with a metallic nucleus. From 2375 and 3150 fathoms, respectively. (× 60.)

40th parallel of south latitude. South of this the ocean gradually shallows towards the Antarctic Continent. . . . The zone between 2000 and 3000 fathoms occupies a much larger portion of the whole area than any of the others, and it is estimated that the mean depth of the whole region is about 2300 fathoms."

The deposits are classified, as usual, into Oceanic and Terrigenous; and under the former are included the Globigerina, Diatom, and Radiolarian Oozes, besides Red Clay, while the latter comprise Blue Mud, Coral Mud and Sands, and Green Sands. A brief section of the memoir is devoted to each of these sediments, and a series of detailed descriptions of typical specimens, with lists of organisms, is appended.

Among the more striking features, perhaps, is the discovery by Capt. Aldrich in the Red Clay area of semi-fossil teeth of Sharks and ear-bones of Whales, more or less encrusted with oxide of manganese, as already observed by the *Challenger* expedition in certain similar regions of the Pacific and Atlantic Oceans. Through the kindness of Dr. Murray we are enabled to reproduce the figures of four such specimens (Figs. 1–4) obtained by the *Challenger*; and it will be noted that two, at least, pertain to species characteristic of the Middle Tertiary and, so far as known, no longer existing.

The hollow shell of a dental crown shown in Fig. 1, is indistinguishable from the well-known fossil tooth discovered in the Miocene or Pliocene of nearly all parts of the world, and ascribed to *Carcharodon megalodon*. Fig. 2 represents a tooth of *Oxyrhina hastalis*, which seems to have an equally wide distribution in Tertiary formations; and another tooth, not figured, is very suggestive of the so-called *Otodus obliquus* of the London Clay. The Cetacean ear-bone shown in Fig. 3 is identified with the existing *Ziphius cavirostris*; and Fig. 4 gives a view, in section, of a manganese concretion formed round an ear-bone of *Mesoplodon*. Small spherules, with metallic iron as a nucleus (Fig. 5), regarded as of cosmic origin, are also found in the Red Clay; and numerous small mineralogical curiosities, including granules of bronzite (Fig. 6), are mingled with the same sediment. "There are indications that volcanic disturbances have taken place at the bottom in these regions, but at a remote period rather than recently." A. S. W.

II.—Geological and Natural History Survey of Canada. Contributions to Canadian Palæontology. By J. F. Whiteaves, F.G.S., etc., Palæontologist and Zoologist to the Survey. Vol. I. Part II. 8vo. pp. 90–196, plates xii.–xxvi. (Montreal, W. F. Brown & Co., 1889.)

PART I. of this series[1] contained only one memoir; the present consists of three, viz.—(1) On some Fossils from the Hamilton Formation of Ontario, with a list of the species at present known from that Formation and Province; (2) The Fossils of the Triassic Rocks of British Columbia; (3) On some Cretaceous Fossils from British Columbia, the North-West Territory and Manitoba.

[1] Reviewed in the Geol. Mag. March, 1886.

Advance copies of the letter-press of these memoirs have already been distributed, pages 91–122[1] having been issued in September, 1887; pages 123–150 in December, 1888; pages 151–184 in June, 1889; while the remainder, or pages 185–196, are dated August 1, 1889.

It may fairly be questioned whether palæontological science is in any way benefited by the practice of issuing advance copies of descriptions of fossils, without any figures to assist in their interpretation. The object of so doing, viz. to secure priority to the author of the species, is, of course, a perfectly legitimate one, but who that has attempted to picture to himself, from a description alone, the form, say of an Ammonite, with all its intricacies of sculpture and suture-line, will not admit that the task has been in too many cases a hopeless one? Good figures have now become indispensable for the accurate identification of species, and not only do new species require them, but many old ones should be refigured from the original types. Such work would greatly lighten the labours of the palæontologist.

However, the volume now under review is amply supplied with figures of all the new species described, in a series of excellent lithographic plates, whose execution reflects much credit alike upon the artist and the lithographer.

The first paper of the series enumerated above contains descriptions of Corals, 1 species, of Crinoids 11, of Blastoids 5, of Brachiopods 11, of Lamellibranchs 2, of Gasteropods 6, of Trilobites 1, and of Fishes 1. Of these the following are considered to be new to science, viz. *Taxocrinus lobatus*, Hall, var., (unnamed), *Homocrinus crassus*, *Dolatocrinus Canadensis*, *Pentremitidea filosa* (doubtfully new), *Lingula Thedfordensis*, *Spirifera subdecussata*, *Platyostoma plicatum*. These are followed by a useful list of fossils from the Hamilton Formation (Middle Devonian) of Ontario.

The author acknowledges his indebtedness to Mr. Charles Wachsmuth for the identification of three species of Crinoids, "as well as for valuable critical suggestions in reference to the Crinoids and Blastoids generally."

It is a pity that so competent a conchologist as Mr. Whiteaves should not have taken upon himself to decide the point as to the affinities of the fossil named by de Verneuil, and later by Professor James Hall, *Turbo Shumardi*, figured on plate xvi. (fig. 3) of the present memoir. Mr. Whiteaves goes no further than to observe that "the reference of this shell to the Linnæan genus *Turbo* does not seem entirely satisfactory, and it is not easy to define in what particular it differs from *Platyostoma*."

The second memoir "On some Fossils from the Triassic Rocks of British Columbia" is prefaced by a brief account of the geographical range of some of the typical species collected, one of which, a species of *Halobia*, is of interest as coming from the most northerly locality on the continent of North America (the Stikine River), from which Triassic fossils have yet been obtained.

[1] Pages 1–90 are contained in Part I. of these Memoirs.

The collection of the Triassic fossils of British Columbia now contained in the Museum of the Survey consists of 3 species of Brachiopoda, 5 of Lamellibranchiata, 1 of Gasteropoda, and 8 of Cephalopoda, besides some undeterminable fragments of *Pentacrinites*. Of these the four following are identified with previously described species, viz. *Terebratula Humboltensis*, *Monotis subcircularis*, *Halobia (Daonella) Lommeli*, and *Arcestes Gabbi*; the remainder are regarded as new, or of uncertain affinities, viz. *Spiriferina borealis*, *Terebratula Liardensis*, *Monotis ovalis*, *Halobia occidentalis*, *Trigonodus* (?) *productus*, *Margarita Triassica*, *Nautilus Liardensis*, *Popanoceras McConnelli*, and variety *lenticulare*, *Acrochordiceras* (?) *Carlottense*, *Trachyceras Canadense*, *Arniotites* (species uncertain), *Arniotites* or *Celtites* (species uncertain), *Badiotites Carlottensis*. Most of the species of Cephalopoda described as new were examined by Professor A. Hyatt, of Boston, whose observations regarding them are appended to Mr. Whiteaves' descriptions. The new genus *Arniotites*, Hyatt, is here jointly described by Mr. Whiteaves and Professor Hyatt, the latter regarding it as the equivalent of the *Balatonites arietiformes* of Mojsisovics. The type-species is the *Celtites* (?) *Vancouverensis* of Whiteaves, described in Dr. G. M. Dawson's "Report of a Geological Examination of the Northern Part of Vancouver Island and Adjacent Coasts" (Ann. Rep. Geol. Surv. Canada for 1886, p. 110 B.)

The third memoir—On some Cretaceous Fossils from British Columbia, the North-West Territory and Manitoba—is divided into the following sections, viz. (A.) "From the Earlier Cretaceous of British Columbia," in which the following species occur:—*Aucella Mosquensis*, var. *concentrica*, *Yoldia arata*, Whiteaves, *Astarte Carlottensis*, n.sp., *Opis Vancouverensis*, Whiteaves, *Placenticeras occidentale*, Whiteaves, *P. Perezianum*, Whiteaves, *P.* (*Perezianum* ? var.) *Liardense*, and *Scaphites Quatsinoensis*, Whiteaves.

(B.) "From the North-West Territory."

(1.) From Rink Rapids, on the Lewis River, a tributary of the Yukon, in Latitude 60° 20′ and Longitude 136° 30′; collected by Dr. G. M. Dawson in 1887.

The following species are recorded from this locality:—*Discina pileolus*, n.sp., *Cyprina Yukonensis*, n.sp., *Schlœnbachia borealis*, n.sp. ?, *Estheria bellula*, n.sp.

(2.) From the Rocky Mountains, three miles north of the east end of Devil's Lake; collected by R. G. McConnell in 1887.

The fossils here obtained are said to be "probably from the same geological horizon as the Lower Shales and Sandstones of the Queen Charlotte Island Cretaceous," and consist of the following, viz. *Terebratula robusta*, n.sp., *Ostrea Skidegatensis*, Whiteaves. *Exogyra* (species undeterminable), *Lima perobliqua*, n.sp., *Pteria* (*Oxytoma*) *Corneuliana*, d'Orbigny, *Inoceramus*, *Trigonoarca tumida*, Whiteaves, *Trigonia Dawsoni*, Whiteaves, *Astarte Carlottensis*, Whiteaves, *Protocardium Hillanum* (?) var., *Cyprina occidentalis*, Whiteaves, *Pleuromya Carlottensis*, Whiteaves, *Schlœnbachia borealis*, Whiteaves, *S. gracilis*, n.sp., *Belemnites* (species undeterminable).

(3.) From the Peace River, a few miles below Fort Vermilion; collected by Mr. W. Ogilvie, D.L.S., in 1885.

Only one species was collected in this locality, viz. *Placenticeras glabrum*, n.sp.

(4.) From the Fort Pierre Group of the Later Cretaceous Rocks of the Saskatchewan and its tributaries; collected by J. B. Tyrrell in 1885 and 1886.

From this locality the following species were obtained, some of which were described in Mr. Tyrrell's Report in the Annual Report of the Survey for 1886 (vol. ii. new series, pp. 153–163 E), but without figures, a want which is here supplied:—*Pteria linguiformis*, var. *subgibbosa*, Meek, *Inoceramus Sagensis*, var. *Nebrascensis*, Owen, *I. Vanuxemi*, Meek & Hayden, *Gervillia recta*, var. *borealis*, Whiteaves, *Tancredia Americana*, Meek & Hayden, *Cyprina ovata*, M. & H., *Cyprina subtrapeziformis*, Whiteaves, *Protocardia subquadrata*, Evans & Shumard, *Protocardia borealis*, Whiteaves, *Linearia formosa*? Meek & Hayden, *Pholadomya subventricosa*, M. & H., *Liopistha undata*, M. & H., *Solecurtis* (*Tagelus*) *occidentalis*, Whiteaves, *Martesia tumidifrons*, Whiteaves, *Hydatina parvula*, Whiteaves, *Lunatia concinna*, Hall & Meek, sp., *Baculites ovatus*, Say, *B. grandis*, Hall & Meek, *B. compressus*, Say, *Scaphites nodosus*, Owen, *Placenticeras placenta*, Dekay, sp., *Palæastacus* (?), *ornatus*, Whiteaves, Tooth of a Selachian.

(C.) "From Manitoba."

From the Niobrara-Benton Formation of the Later Cretaceous in the Duck and Riding Mountain District. Here the following species have been collected:—*Serpula semicoalita*, n.sp., *Lingula subspatulata* (?), Hall & Meek, *Ostrea congesta*, Conrad, *Anomia obliqua*, Meek & Hayden, *Inoceramus problematicus*, Schlotheim, *Modiola tenuisculpta*, n.sp. (?), *Belemnitella Manitobensis*, n.sp., *Loricula Canadensis*, n.sp., *Ptychodus parvulus*, n.sp., *Lamna Manitobensis*, n.sp., *Enchodus Shumardi*, Leidy, *Cladocyclus occidentalis*, Leidy.

A. H. F.

III.—Notes on the Jurassic and Cretaceous Strata of Russia and England. By Prof. A. Pavlow.

Etudes sur les Couches Jurassiques et Crétacées de la Russie. I. Jurassique Supérieur et Crétacé Inférieur de la Russie et de l'Angleterre. Par le Prof. A. Pavlow. Bulletin de la Soc. Imp. de Moscow, 1889, No. 1, pp. 61-127, 176-179, Pls. II., III., IV.

CONFLICTING opinions touching the relative age and position of a series of strata in the higher portion of the Jurassic and the lower portion of the Cretaceous in the East of Russia, have for a long time existed among Russian palæontologists, and curiously enough the question as to the proper correlation of the strata on the same horizons in this country is still a debated point, as shown in the excellent paper "On the Subdivisions of the Speeton Clay," brought recently before the Geological Society by Mr. G. W. Lamplugh. Prof. Pavlow has studied for many years the Russian beds, developed more particularly near Simbirsk on the Lower Volga, and in the neighbourhood of Moscow, and last year he made a personal

examination of the section at Speeton, and of the fossils therefrom in the Woodwardian and other museums of this country, with the result of discovering a very close resemblance in the fossils and petrographic character of these beds in the two countries, so that there can be no doubt that they should be considered as synchronic or homotaxial. The points of similarity and difference in the deposits and the fossils are discussed in considerable detail in the present paper, and the following are the conclusions arrived at by the author: (1) The beds with *Perisphinctes virgatus* of the East of Russia immediately overlie the strata with *Hoplites eudoxus* and *Exogyra virgula* (Middle Kimmeridge), and are intimately related to these latter. (2) The Russian strata with *Perisphinctes virgatus*, correspond to the Upper Kimmeridge of English geologists (Blake), to the Lower Portlandian, and, in part, to the Middle Portlandian of the French geologists (Loriol). (3) The zone of *Olcostephanus triplicatus*, or the Lower Portland of Blake, exists in the Russian Jura, and serves as base to the beds with *Oxynoticeras catenulatum* (the first étage of Rouillier). (4) Judging by its stratigraphical relations, this first étage with *O. catenulatum*, cannot be more recent than the Upper Portland. (5) The bituminous schists of the Province of Simbirsk and those of Speeton are on the same geological horizon. (6) The zone of *Belemnites lateralis*, Phill. (*corpulentus*, Nik.), of Simbirsk, and the first étage of Rouillier, correspond to the zone at Speeton of this same fossil, and, consequently (7) the *Bel. lateralis* zone at Speeton corresponds to the Upper Portland of the South of England. (8) The gravels of Spilsby, Lincolnshire, are nearly equivalent to the *Bel. lateralis* zone of Speeton, and to the corresponding beds in Russia. (9) Between the zone of *Bel. lateralis* (*corpulentus*) and the Neocomian beds of Simbirsk there is a well-marked unconformity, which (10) nearly coincides with the epoch of *Hoplites noricus* and *Bel. jaculum* (type). (11) The zone at Speeton with *Amm. speetonensis* corresponds to the lower part of the Neocomian clays of Simbirsk (clays with *Olcost. versicolor* and *Inoceramus aucella*). (12) The fauna of the higher stages of the Russian Jura (first and second étages of Rouillier, Volgien inférieur et supérieur) is so intimately allied to that of the corresponding stages in England, that it is possible and desirable to adopt a common stratigraphical classification for the two countries.

The author further shows in tabular form the corresponding zones in the two countries, and describes and figures some of the principal fossils, including new species of *Olcostephanus* from Swindon, and Spilsby, as well as from Simbirsk.

IV.—Prof. F. Fouqué on Earthquakes.

Les Tremblements de Terre. By F. Fouqué, Membre de l'Institut (Académie des Sciences), Professeur au Collège de France. 328 pp. (Paris, J. B. Baillière et Fils, 1888.)

As the whole of Prof. Fouqué's book will repay a careful study, this notice may be confined to one or two passages that seem to me to admit of improvement, and a few others as being worthy of especial attention from geologists.

In a recent work on Earthquakes, we should expect to find a fair discussion of some of the excellent seismographs which have lately been invented in Japan and other places. M. Fouqué excuses himself from the task of writing such a chapter (pp. 7–8), partly on the ground that the subject deserves to be treated in a separate work; partly because improvements are continually being made in these instruments, and their description will gain by being deferred for some years. If this latter principle were consistently carried out, how many works on natural science would ever see the light? But the influence of these reasons is not very apparent. For the average length of one of M. Fouqué's chapters is a little less than 18 pages; and the scattered references to seismographs and other instruments amount to rather more than 20 pages, excluding the description of those used in the experiments on the velocity of earth-waves. Now, of these twenty pages, seven are devoted to Cavalleri's seismoscope and some of the results that have been obtained with it. But, owing to the fact that the period of vibration changes during an earthquake, and to the natural defects of the instrument itself, these pages are of little value. Of other instruments alluded to, the accounts are too short and incomplete to be of much use, and in only one case is the description accompanied by a figure. It is to be hoped therefore that, in a new edition, M. Fouqué will see his way to replacing these twenty pages by a chapter in which a few of the more trustworthy seismographs are exactly figured and described.

In the chapter on the "centre of disturbance," the approximate and imperfect nature of our methods for determining its superficial position and depth is carefully pointed out. The method employed by Messrs. Dutton and Hayden, in the case of the Charleston earthquake, is however quoted with some approval. But this method makes the depth of the centre independent of the intensity of the initial disturbance. For instance, in every earthquake originating at a depth of $3\frac{1}{2}$ miles, the intensity would, if the method were correct, decrease most rapidly at a distance of about two miles from the epicentrum. But we can imagine the intensity of the earthquake to be so feeble initially that it cannot, by the most delicate instrument yet constructed, be felt at so great a distance from the epicentrum, or perhaps even be felt at the surface at all. The method is thus unreliable, however carefully applied. Perhaps a more accurate statement of it would be that it gives an inferior limit to the depth of the seismic focus.

Microseismology, one of the latest and most fascinating developments of the science, is dismissed in a short chapter of a dozen pages. Half of the chapter is allotted to the perturbations of magnetic instruments during earthquakes. But, whilst these interesting pages could ill be spared, might we not have expected a fuller account of the other advances that have recently been made? Such a chapter must surely be incomplete when the names of Bertelli, the founder of microseismology, of d'Abbadie, and the Darwins are not so much as mentioned.

The rotation of columns during earthquakes is an interesting

historical problem, and M. Fouqué adheres to the original explanation of Mallet. He seems (p. 55) to doubt the real existence of vorticose shocks, whereas it is evident, as was shown some years ago in this MAGAZINE (Vol. IX. 1882, pp. 257–265), that such shocks in the neighbourhood of the epicentrum are a necessary consequence of a large seismic focus, and may be one of the causes of the rotatory movement so frequently observed. The cause suggested by Mr. Gray is probably, however, that which acts most widely in producing this effect.

It would be difficult, within reasonable limits, to point out the many excellences of Prof. Fouqué's book. But as, in this country, it will probably be read chiefly as a supplement to that written by our leader in seismology, Prof. Milne, it may be well to note the passages that, in this view, will best repay perusal. First and foremost is the admirable treatment of the relations between earthquakes and geological structure, the evolutionary aspect of the science (pp. 9–30, 189–201). Here we have discussed and summarized the work of Suess, Höfer, von Lasaulx, Hoernes and others, as well as some of the earlier results obtained by the Swiss Seismological Commission. The subject of seismic periodicity is considered with great fullness in Chapter x. The useful list of questions drawn up by Prof. Heim for aid in the study of earthquakes is reprinted in Chapter viii. The velocity of earth-waves occupies a long and interesting chapter, and includes an account of the valuable experiments made by the author in conjunction with M. Lévy. Lastly, the second part of the book (pp. 249–326) contains a description of a few of the more important earthquakes that have happened between 1854 and 1887.

The illustrations, with one or two exceptions, are good; and among them may specially be noticed the maps of the Swiss earthquakes of Nov. 1879—Dec. 1880, and of July 22, 1881, the Charleston earthquake of August 31, 1886, and the Andalusian earthquake of Dec. 25, 1884.

C. DAVISON.

V.—REYNOLDS'S GEOLOGICAL ATLAS OF GREAT BRITAIN. Comprising a series of County Maps geologically coloured from the best authorities.[1] Second Edition, 1889.

ANY book which calls for a new edition, by reason of its intrinsic value, is worthy of notice. A new edition of the well-known Geological Atlas of Great Britain, published by Messrs. Reynolds & Sons, 174 Strand, has just been issued. This atlas comprises 32 county maps geologically coloured and arranged alphabetically, the colours depicting the varied geological features of each county are mainly those used on the published maps of the Geological Survey.

Every county is carefully coloured, and the colours numbered

[1] Published by James Reynolds & Sons, 174 Strand, 1889.

according to the legend for geological reference separately given at the commencement of the atlas, of which there are 30 divisions. The execution of the maps geologically and topographically leaves little to be desired; this atlas, in fact, forms a most perfect pocket travelling companion, combining both convenience and portability, with clearness and accuracy; we commend this work to all travellers in Great Britain.

Advantage has been taken of the advanced state of the Geological Survey maps, to correct and re-draw the geological lines, and depict the solid geology as accurately as possible. The want of a new edition of this atlas has long been felt by those who have used the first one, its completeness and portability for ready reference either for the library or as a companion in the field, render it indispensable.

Each map is accompanied by a small skeleton index to the numbered and published sheets ($\frac{1}{4}$ or whole) of the 1-inch geological maps of the Survey, and the divisional lines upon each of the maps of the atlas also correspond to the area occupied by them. This enables any one to order the special maps of the Survey from which the 32 counties in the atlas have been constructed.

Marginal notes are appended to each map, denoting the places of occurrence of the more important organic remains, as well as of the economic minerals met with in the county. Examination of maps 8, 10 and 11, or, indeed, any others, will readily show the usefulness and value of these notes to those seeking mineralogical, geological, or palæontological information.

Twenty-three pages of letterpress (p. 1–23), containing short geological descriptions of the 32 maps, will be found of value and interest, as affording a short description of the structure of each county. Pages 24–32 are devoted to the mineral products of Great Britain, their distribution and value. Agricultural geology and water supply receive attention. A most admirable tourists' guide of 10 pages, giving the chief places of interest, finest views and scenery, fishing stations and streams, etc.; indeed, in relation to each of the 32 counties, matters of much general interest and use are given.

Probably no other work of the kind will so readily commend itself to, or meet the requirements of, the traveller by rail or road, and the construction of the maps will satisfy the most critical, as fulfilling the purpose for which they are published as an atlas of England geologically illustrated. A geological map of Scotland accompanies the atlas; it is to be regretted that Messrs. Reynolds & Sons did not prepare an equally good geological map of Ireland to accompany it.

We recommend this extremely good and well-got-up book to all who desire to know something of the geological structure of Great Britain.

VI.—New Map of the Environs of London geologically coloured. Scale ½-inch to the Mile.[1]

THIS will prove to be a very useful Geological Map of the London area. The high price of the two 1-inch maps of the Geological Survey illustrating the same district deters many from possessing a reliable map of the complicated geological structure of the London Basin. This map issued by Messrs. Reynolds & Sons quite supplies the want. The geological lines are correctly laid down, being taken and reduced from the larger one-inch Ordnance Geological Map.

London in both cases is placed in the centre of the sheet [this was expressly arranged in the Survey map for the convenience of its many inhabitants]. The two maps issued by the Geological Survey exhibit two important features over the London area, one showing the solid geology and the other the superficial or more modern Post-Pliocene accumulations; this is partly done on the map before us, but to have placed all the Quaternary sands, gravels, and clays (as depicted on the Survey map) on this map (on half the scale) would have been at the expense of clearness of definition. The superficial area of the map is 2280 square miles or 60 miles by 38. London being in the centre, gives a radius of 30 miles east and west, and 19 miles north and south; concentric lines four miles apart denote distance in miles from the centre of London. The east and west of the country illustrated extends from Long Reach east of Chatham to Laurence Waltham west of Maidenhead. Latitudinally the area extends from Godalming, Guildford, and Tunbridge on the south, to St. Albans and Chelmsford on the north. The area covered by the one-inch Survey map is 1144 square miles or 44 by 26 miles; thus Messrs. Reynolds' map contains geological information over 1136 more square miles than the Government sheet. The structural or physical lines are carefully laid down over the entire map, the geological epochs shown on the map, ranging from the Weald Clay to the Post-Tertiary, or Post-Pliocene beds of the Thames Valley, etc., all the railways are well defined, a desideratum for scientific as well as ordinary travellers, and the stations are prominently marked.

The colours illustrating the geological formations are numbered to correspond with the legend, thus leaving little to be desired as a thoroughly convenient map of the Environs of London both topographically and geologically constructed.

Thirty-three pages of letterpress accompany the map, naming and describing no less than 152 places of interest within the radius of 30 by 19 miles, being a clear and general history of the more remarkable places in the counties of Middlesex, Surrey, and Essex. On p. 15 a short account is given of the geology of the London area, tersely explanatory of the varied geological formations that occur within the area depicted. We commend this map, published by Messrs. Reynolds & Son, to all residents in London and its environs, also to travellers and geological students.

[1] Published by James Reynolds & Sons, 174, Strand, 1889.

CORRESPONDENCE.

RATE OF SUBAËRIAL DENUDATION.

SIR,—Referring to Mr. Davison's paper in the September Number of the GEOLOGICAL MAGAZINE, it will not do, as I have endeavoured to show in "Stellar Evolution," to take the average rate of denudation of the seven river basins which he names, as in any way representing the mean denudation of the whole earth. The majority of these rivers are exceptionally muddy, indicating a very high rate of denudation: much above that of the whole earth.

PERTH. JAMES CROLL.

THE FULLERS EARTH OF NUTFIELD.

ERRATUM.—Mr. P. Gerald Sanford regrets that some mistakes occurred in the setting up of the figures of his analysis of the "Fullers' Earth." GEOL. MAG. October, 1889, p. 456, which he desires now to correct.

No. 1. BLUE EARTH.

Dried at 100° C				Insoluble Residue.		
Insoluble Residue	= 69·96	per cent.	=	SiO_2	= 62·81	per cent.
Oxide of iron, Fe_2O_3	= 2·48			Al_2O_3	= 3·46	,,
Alumina, Al_2O_3	= 3·46			Fe_2O_3	= 1·30	,,
Lime CaO	= 5·87			CaO	= 1·53	,,
Magnesia, MgO	= 1·41			MgO	= 0·86	,,
Phosphoric acid, P_2O_5	= 0·27	Soluble				
Sulphuric acid, SO_3	= 0·05	in acid.			69·96	
Sodio Chloride, NaCl	= 0·05					
Alkalies, K_2O	= 0·74					
Combined Water	= 15·57					
	99·86					

P. G. SANFORD.

OBITUARY.

CHARLES SPENCE BATE, L.D.S.R.C.S. ENGL., F.R.S., ETC.

BORN 16 MARCH, 1818; DIED 29 JULY, 1889.

CHARLES SPENCE BATE was born at Trennick, Truro, on the 16th March, 1818. He was the eldest son of Mr. Charles Bate, who for many years practised as a dentist in Plymouth. He was educated at the Truro Grammar School under the late Dr. Ryall. On leaving school he entered the surgery of Mr. Blewett, where he remained about two years; he then devoted himself to the study and practice of dentistry with his father. After becoming duly qualified, he removed, in 1841, to Swansea, where he soon acquired a considerable practice. While at Swansea he developed an ardent love for Natural History, by his knowledge of which he afterwards became distinguished. He was speedily associated with all the scientific men of the place; and on the occasion of the visit of the British Association to the town in 1848, he took an active part in arranging for the reception of that body, and became one of its members. On more than one occasion subsequently he was President of one of the Sections. He was mainly instrumental in securing the visit

of the British Association to Plymouth in 1877; and as one of the Vice-Presidents at that meeting, he contributed largely by his liberal exercise of hospitality to make the gathering a success.

In 1851 Mr. Spence Bate left Swansea and returned to Plymouth, taking up his residence at 8, Mulgrave Place, where he succeeded to the practice of his father as a dentist, in which profession he was almost unrivalled. He was the author of many works on dentistry, which appeared separately, or in the "Lancet," the "British Journal of Dental Science," and the "Medical Gazette," and in the "Transactions of the Odontological Society," to the Presidency of which he was elected in 1855. Two years previously he had been President of the British Dental Association. In 1881 Mr. Spence Bate was a Vice-President of a section of the Medical Congress. He was Honorary Surgeon-Dentist to the Plymouth Dental Dispensary and other local Institutions.

Nor was it only in dentistry that Mr. Spence Bate became celebrated. He devoted a large amount of time to the investigation of the habits of marine animals, and, in conjunction with Mr. I. O. Westwood, was the author of a most important work on the "British Sessile-eyed Crustacea." The value of this work was fully recognized by the scientific world, and for this and other Memoirs on the Crustacea, Mr. Bate was elected a Fellow of the Royal Society in 1861. Other works by him on the same subject were a British Museum "Catalogue of Amphipodous Crustacea," and a "Report on the Crustacea Macrura, collected by H.M.S. 'Challenger,'" during the cruise of that Vessel round the world. This last-named work was only completed a year ago, and forms a most valuable contribution to carcinological science.

He was keenly interested in all scientific matters connected with the town of Plymouth and county of Devon, and earnestly exerted himself to promote their progress and success. The restoration of the Plymouth Institution to its present healthy activity, after a period of comparative inertness, must be mainly ascribed to him.

Elected a member of the Institution in 1852, he became Secretary 1854–60, President in 1861–62 and 1869–70, and Member of Council 1853–83. He served as Museum Curator at different times, and as Editor of the Transactions in their present form 1869–83. He delivered no fewer than thirty lectures and Presidential Addresses between 1853 and 1882 to this Institution.

Mr. Bate was one of the founders of the Devonshire Association, and during the first year of its existence (1862) was Senior General Secretary. In the following year he vacated this post, having been elected to the office of President of the Association. He delivered his Presidential Address at the Annual Meeting at Plymouth in 1863, and qualified as a permanent member of the Council. He was seldom absent from the annual meetings, and never ceased to take the liveliest interest in the progress of the Association. Between 1862 and 1873 he contributed eleven papers to its Proceedings.

He was an Honorary Member of the Torquay Natural History Society, Honorary Member of the Teign Naturalists' Field Club, and likewise Honorary Member of the Royal Institution, Truro.